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TESIS DOCTORAL:

Supporting Practitioners in the Gamification of MOOCs through Reward-Based Strategies

Presentada por

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Resumen

Los MOOC (cursos masivos y abiertos en línea) han surgido como complemento o alternativa a otras formas de enseñanza y aprendizaje más tradicionales (p.ej., las clases presenciales). A pesar de los beneficios que ofrecen este tipo de cursos (p.ej., acceso abierto a contenidos de universidades prestigiosas), la baja implicación de sus estudiantes se ha identificado como una limitación importante, contribuyendo al alto abandono de este tipo de cursos. En este contexto, el uso de las denominadas "gamificaciones" basadas en recompensas se postula como una estrategia prometedora para incrementar dicha implicación, considerando sus effectos positivos observados en otros contextos educativos de baja escala. Sin embargo, este tipo de estrategias llevan asociadas una serie de tareas de orquestación (p.ej., diseño, instanciación, gestión), que tienen que ser realizadas por los diseñadores y/o profesores de dichos cursos. Así, esta tesis pretende dar apoyo a estos profesores en el diseño, instanciación y gestión de estrategias basadas en recompensas en entornos MOOC, para incrementar la implicación de los estudiantes. Con tal fin, este trabajo propone la consecución de tres objetivos, siguiendo la metodología SDRM (*System Design Research Methodology*).

El primer objetivo tiene que ver con entender si el uso de este tipo de estrategias realmente tiene un efecto beneficioso en el comportamiento y la implicación de los participantes de MOOC. Las características específicas de los MOOC (p.ej., número masivo de estudiantes, heterogeneidad de los participantes, interacción asíncrona) comprometen los beneficios observados en entornos de aprendizaje de baja escala. Una revisión sistemática de la literatura realizada en el contexto de esta tesis, reveló la carencia de estudios empíricos en entornos MOOC reales, de forma que, los efectos positivos esperados de estas estrategias no han podido todavía ser confirmados. En este sentido, dentro del marco de esta tesis, se realizaron tres estudios empíricos de MOOC implementando este tipo de estrategias, ayudando así a entender sus efectos, y recogiendo evidencias para la creación de potenciales guías de diseño que pueden ser útiles para el diseño de futuros MOOC.

El segundo objetivo hace referencia a la necesidad de proporcionar a los profesores, diseños MOOC con estrategias basadas en recompensas que puedan ser interpretados computacionalmente, contribuyendo a su instanciación y gestión automática (p.ej., la entrega de recompensas). Un análisis de características de plataformas MOOC y sistemas de gamificación permitió identificar sus limitaciones en relación con la representación computacional de este tipo de estragias en las herramientas nativas de las plataformas MOOC. Ante esta situación, esta tesis presenta un modelo de datos (GamiTool-DM), que apoya la representación de estas estrategias en MOOC con un alto nivel de detalle, permitiendo así, alinear las decisiones pedagógicas de los instructores, con sus intenciones de gamificación.

El antes mencionado análisis de características también reveló que los sistemas de gamificación y plataformas MOOC presentan ciertas limitaciones en relación con el coste cognitivo y temporal de la orquestación de estas estrategias (p.ej., herramienta visual de autoría, despliegue y gestión automática de recompensas). Así, el tercer objetivo de esta tesis pretende hacer que el coste de diseño, instanciación y gestión de estas estrategias en MOOCs sea asequible para sus profesores. Para alcanzar este objetivo, este trabajo propone un sistema (GamiTool), que incorpora el anterior modelo de datos y una arquitectura tecnológica (GamiTool-ARCH), apoyando a través de sus características el uso asequible

de estas estrategias en varias plataformas MOOC. Un prototipo desarrollado de GamiTool (incluyendo GamiTool-DM y GamiTool-ARCH) ha sido iterativamente refinado y evaluado con profesores de MOOC, de acuerdo con el segundo y tercer reto de esta tesis. Los resultados de los estudios de evaluación mostraron el cumplimiento de los objetivos de esta tesis y vislumbraron futuras direcciones de investigación en el área de gamificación en entornos educativos en línea y masivos.

Palabras clave

MOOC, gamificación, estrategias basadas en recompensas, implicación de los estudiantes, sistema, profesor, diseñador, revisión de la literatura, análisis de características, estudio empírico, modelo de datos, arquitectura tecnológica, GamiTool.

Abstract

Massive Open Online Courses (MOOCs) have been established as a complement or alternative to other more traditional forms of teaching and learning (*e.g.*, face-to-face, blended learning). Despite their relevant benefits (*e.g.*, open access to education from prestigious universities), student disengagement has been identified as an important shortcoming, contributing to high drop out rates. In order to overcome this problem, reward-based gamification has been proposed as a promising strategy to increase student engagement in MOOCs, following its success in other small-scale educational contexts. However, the addition of gamification strategies implies a number of orchestration tasks (*e.g.*, design, instantiation, management) that have to be carried by course practitioners (instructional designers, instructors, teacher assistants, etc.). Given this context, this dissertation aims to support MOOC practitioners in the design, instantiation and management of reward-based strategies in MOOC environments to promote students' engagement. To this end, this dissertation proposes the attainment of three goals by following the System Design Research Methodology.

The first goal deals with understanding whether reward-based strategies provide fruitful effects on student engagement in MOOCs. The distinctive features of MOOCs (*e.g.*, massive number of participants, participants' background heterogeneity, asynchronous interaction) might compromise the benefits observed in small-scale educational environments. A systematic literature review performed within the context of this dissertation, revealed a lack of empirical studies performed in real MOOC environments, thus hindering the understanding of how these strategies affect student engagement. In this sense, three empirical studies were carried out in the context of this dissertation. The three studies involved MOOCs that incorporated reward-based strategies, helping understand their effects, and gaining insights about potential design guidelines that might eventually be used by practitioners in the design of future MOOCs.

The second goal refers to the need of providing practitioners with computer-interpretable models to represent MOOC learning designs, incorporating reward-based strategies, thus supporting their automatic instantiation and management (*e.g.*, reward-issuing procedure). A feature analysis of MOOC platforms and gamification systems identified their limited support regarding the representation of reward-based strategies in MOOC platforms' native tools. Given this context, this dissertation presents a data model (GamiTool-DM) that supports the computer-interpretable representation of reward-based strategies in MOOCs with a fine-grained level of detail, thus allowing to align practitioners' gamification purposes with the course pedagogical goals.

The aforementioned feature analysis also revealed that current MOOC platforms and gamification systems present some limitations regarding the cognitive and timely affordable orchestration of these strategies (*e.g.*, usable authoring tool, automatic deployment and reward-issuing procedure). Consequently, the third goal of this dissertation aims to make cognitively and timely affordable for practitioners, the design, instantiation and management of reward-based strategies in MOOCs. In order to achieve this goal, this dissertation proposes a system (GamiTool), incorporating the previous data model and a system architecture (GamiTool-ARCH), supporting such affordable orchestration for a variety of MOOC platforms. A prototype of GamiTool (including GamiTool-DM and GamiTool-ARCH) has been iterative refined and evaluated with MOOC practitioners re-

garding the second and third goals of this dissertation. The results of these evaluation studies showed the accomplishment of such goals and relevant directions for future research in the area of gamification in MOOCs, and online educational environments.

Keywords

MOOC, gamification, reward-based strategies, student engagement, system, practitioners, literature review, feature analysis, empirical study, data model, technological architecture, GamiTool.

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Chapter 1

Introduction

Summary: This chapter describes the general research context of this dissertation, the research question, the overarching objectives and the methodology followed to attain them. The dissertation deals with the orchestration of reward-based strategies in Massive Open Online Courses (MOOCs). More concretely, we intend to provide conceptual and technological tools to support practitioners (*e.g.*, instructional designers, instructors) in the design, instantiation and management of MOOCs involving reward-based strategies. Additionally, we aim to extend the current and limited body of empirical research about the educational impact associated to the use of different types of reward-based strategies in real MOOC settings. By following the System Design Research Methodology, we propose two main contributions to help overcome three current problems associated to the orchestration of these strategies in MOOCs: an analysis of the effect of reward-based strategies on MOOC participants, and a system to support the orchestration of reward-based strategies in MOOCs. The contributions have been evaluated and refined throughout the research process by means of three empirical studies performed in MOOC contexts, and a set of studies with experts acting as MOOC gamification designers.

1.1 Motivation

The evolution of technology during the last decades has nourished the use of Information and Communication Technologies (ICT) supporting teaching and learning practices. In this way, the **Technology Enhanced Learning (TEL)** research field [22, 81] aims to improve existing teaching and learning processes, facilitating the access to learning, increasing students' engagement, improving learning outcomes, etc. The recent advances in technology, and the evolution of traditional teaching-learning models, have led to the creation of learning management systems [49] that incorporate contents and resources for thousands of students at the same time, the so-called 'Massive Open Online Courses'.

Massive Open Online Courses (MOOCs) are conceived as a form of global education that balance the traditional and structured classroom-based environments with open and disperse information available on Internet [264]. The combination of conventional digital teaching tools (*e.g.*, videos, readings, or slides), individual and collaborative online tools for acquiring and assessing students' knowledge (*e.g.*, simulators, questionnaires),

and dedicated social networks (*e.g.*, discussion forums, Twitter[1]) offers a potentially effective and affordable opportunity to access knowledge [73]. MOOCs have brought important benefits to the educational community since their first appearance in 2008 [264, 52]: open access to high quality learning contents on demand offered by prestigious universities, new forms of certification in education, the creation of learning communities around a shared topic, new forms of outsourcing for universities, etc. [88, 64]. However, despite the substantial growth in the number of MOOCs as well as the number of students enrolling in them every year [254, 255], **low completion rates still remain as a significant issue** [133, 4, 140, 230].

In this context, a certain percentage of dropouts can be expected according to the different profiles enrolling in MOOCs (with different personal goals and interests) [150, 3, 87, 169]. However, many dropouts seem to be linked to the pedagogical models and instructional designs applied [246, 178, 120], failing to engage learners with course contents and activities [140, 141]. Previous research studies have shown the benefits of using **strategies supporting students' active learning**[2] to improve learners' engagement, increase course retention rates, and decrease the low levels of participation [88, 127]. One pedagogical strategy that has attracted the attention of MOOC practitioners and researchers during the last years is the so-called *gamification* [59, 144, 138], due to the benefits already shown in other educational contexts [111, 61, 67].

Gamification is defined as the inclusion of elements and structures that frequently appear in games (*e.g.*, rewards, narrative, engagement loops) in non-game contexts [65, 61]. This technique has already shown potential to enhance user motivation and engagement in diverse online contexts (*e.g.*, Nike+ running app, airlines' frequent flier milestones), including educational environments [285, 67]. Gamification in education tries to replicate the learner benefits shown through *game-based learning* [221] while avoiding the creation of a whole game or video-game experience [130]. Particularly, gamification approaches have shown to be **effective in promoting students' motivation and engagement in online and blended learning environments**, thus supporting their learning and achievement [61, 111, 67]. During the last years, there has been an increasing number of research works proposing the use of **gamification strategies in MOOCs** to enhance students' motivation and engagement in such massive courses [144, 12, 210, 132, 238].

According to previous literature reviews on gamification in education [111, 67, 210], rewards are the most used game elements in online educational contexts, generating the so-called ***reward-based gamification*** [200] or *incentive systems* [156]. In this type of gamification, students are awarded or prompted with *game elements* (*i.e., rewards*) integrating a *signifier* (*e.g.*, name, visual, description) when a *completion logic* (*i.e.*, conditions defined beforehand) is satisfied [110, 109]. For example, students can get a ribbon (*reward*) with a concrete visual representation and description (*signifier*) when submitting three optional course tasks (*completion logic*). Among the multiple reward-based elements, points, badges and levels are the most implemented reward types in online educational environments [67, 278, 163]. Additionally, points, badges, virtual goods and redeemable rewards have been identified as highly motivating rewards by MOOC learn-

[1] Twitter: *https://twitter.com/*, last access: September 2020.

[2] According to Bonwell and Eison (1991) [31], *active learning* can be defined as the *"instructional activities involving students in doing things and thinking about what they are doing (e.g., read, write, discuss)"*.

ers [43]. However, although there exist previous studies integrating reward-based gamifications in online and blended learning courses with positive results on student retention [143, 154] and engagement [202, 75, 130, 25, 8], **there is a scarcity of empirical research on the effects of reward-based strategies in MOOC environments**.

Furthermore, despite these potential benefits of reward-based strategies to help overcome the aforementioned MOOC drawbacks, gamification increases the complexity of the already complex MOOC orchestration[3] for practitioners[4]. In addition to the video recordings, content and activity creations, and the management of learners' doubts and problems during course run-time (all of them examples of tasks under the umbrella of the orchestration metaphor), **the introduction of gamification in MOOC platforms brings an additional burden to practitioners that, in most cases, are not technologically skillful** [52]. Existing literature reviews show the limited research reported about instructor-related challenges in MOOCs [273], and gamification is not an exception [7]. Therefore, this dissertation targets three aspects of MOOCs incorporating reward-based strategies that imply a significant increase in the orchestration load of MOOC practitioners:

- Reward-based strategies have been largely explored in small-scale educational environments [41, 194, 61, 67, 66], showing important **benefits on student behavioral engagement** (*i.e.*, the observable behaviors representing student involvement in learning and academic success [95]). However, **MOOCs have specific features** different from other educational environments (*e.g.*, face to face or blended courses) which may have **significant implications** on how reward-based strategies affect to students [208]. For example, the openness and massiveness features of MOOCs lead to a broad variety in participants' background, knowledge, learning culture and goals as opposed to the limited diversity in formal education settings where practitioners can recognize their students' characteristics and goals (*e.g.*, university course). Therefore, **MOOC practitioners can eventually face issues to design challenging and engaging reward-based strategies** without leading to states of either boredom (over-simple) or anxiety (over-challenging) [57]. Given this context, the expected gamification benefits on student engagement might not be achieved and even turn into negative counter effects. Currently, there is a scarcity of empirical studies analyzing the effects of reward-based strategies on student engagement in real MOOC contexts [12, 210, 144], and most of them consider gamification as a whole (*i.e.*, analyzing the effects of multiple game elements without isolating the effect of reward-based strategies). Research on the empirical effects of could help researchers to derive good practices, guiding practitioners during the instructional design of MOOCs integrating reward-based strategies.

- MOOCs are characterized for having a massive number of worldwide learners interacting with the course at the same time during the 24 hours. In this context, **the**

[3] According to Prieto-Santos (2012) [222], *learning orchestration* refers to *"the complex process of coordinating a teaching/learning situation, from the point of view of the teacher"*. The five main orchestration aspects identified are: design, regulation, adaptation, awareness and the roles of the practitioners [222].

[4] For convenience, throughout this dissertation we will refer to *MOOC practitioner* as any person involved in the orchestration of gamification strategies in MOOCs, including instructional designers, instructors and teaching assistants.

manual management of the rewarding process turns unmanageable for practitioners (*e.g.*, checking the conditions satisfaction, issuing the rewards). Additionally, the manual management of reward-based strategies in these massive environments hinders the provision of frequent and rapid rewarding feedback, potentially failing to engage participants with the course and reward elements [77]. Therefore, **it would be desirable the existence of configurable systems, able to automatize gamification-related tasks taking into account design decisions made by the MOOC practitioners**. To this end, design decisions would need to be explicitly represented using a computer-interpretable format, which could be then interpreted and automated by technological systems. This approach of making practitioners' design decisions explicit (even using computer-interpretable representations) is the main goal of the so-called Learning Design (LD) field [174]. Researchers working in the LD field have proposed different approaches for the computer-interpretable representations of practitioners' design decisions (known as *learning designs*[5]), as well as software tools (known as *authoring tools* or *learning design editors*) for their creation, edition, and manipulation [19]. Thus, computer-interpretable learning designs including reward-based strategies might enable their interpretation according to practitioners' design decisions.

- In most cases, **MOOC production and launch is time consuming and implies a high workload** [73, 76]. Practitioners are responsible for creating the MOOC learning design considering platform constraints, creating and sharing the contents (including video recordings, speeches, presentations, etc.); uploading and configuring the contents and activities to the platform; and, managing course run-time issues and student questions. When using gamification, practitioners are also responsible of (i) gamifying the learning design (*e.g.*, create the rules, select the conditions and rewards) according to the desired intentions they want to promote; (ii) implementing the gamification design in the platform (or hardcoding it in some cases [143]); and, (iii) managing the evolution of gamification during course run-time (*e.g.*, watch over the effect of rewards on student behavior). All these gamification-related activities imply an extra time and effort [69] added to the existing work already employed by practitioners to produce and launch a MOOC, **which can suppose a limitation in the use and adoption of gamification strategies in MOOC environments**. Therefore, gamification systems are expected to support practitioners in the affordable orchestration[6] of these strategies in MOOC contexts.

Currently, there are some systems and applications providing instructors with support in the orchestration of reward-based strategies in MOOC environments. However, most of these works: propose *ad-hoc* systems or solutions tied to a specific technology or MOOC platform (*e.g.*, [267, 21]); do not provide enough flexibility in the digital representation

[5] According to Hernández-Leo (2007) [122], *learning design* aims to *enable the creation of complete, abstract and portable descriptions of any pedagogical approach taken in a course (or part of a course) which can be realized by a compliant system.*

[6] For the sake of clarification, we refer to *affordable orchestration* as the level to which practitioners perceive that the extra workload added by including gamification strategies is balanced with the expected benefits.

and alignment of reward-based strategies with learning contents (*e.g.*, [280, 226]); and, do not tackle the issue of how costly it is for practitioners that are not experts in ICT, to put these strategies in practice in authentic MOOC settings (*e.g.*, [40, 217]). These current limitations can have a negative effect in the attainment of the expected gamification and pedagogical goals, in the affordability of using these practices, and in the end, in the adoption of gamification strategies in MOOC environments. In other words, practitioners are unlikely to use reward-based strategies if they cannot promote concrete desired actions and achieve the expected benefits, and if their design, implementation and management will consume excessive time and/or effort.

The rest of the chapter introduces the work carried out in this dissertation to overcome the aforementioned limitations. Section 1.2, details the main dissertation goal and the partial objectives in which the research problem has been framed; Section 1.3 describes the research methodology that has been used throughout the dissertation; and finally, Section 1.4 summarizes the structure and contents of the rest of the dissertation document.

1.2 Dissertation Goals and Contributions

Given the research context described before, this dissertation addresses the following general problem:

> ***How to support MOOC practitioners in the design, instantiation and management of reward-based strategies in MOOC environments to promote students' behavioral engagement?***

In this dissertation, we aim to understand the support currently provided to practitioners for designing, instantiating and managing their reward-based strategies in MOOCs, and contribute with conceptual and technological tools to improve them and make them more affordable. Additionally, before providing such support, we aim to contribute with a set of empirical studies to understand the effect of reward-based strategies in real MOOC settings, and to gather useful insights for the design of the conceptual and technological tools proposed by the thesis. In order to answer the research question posed in this dissertation, we propose the attainment of the following three partial objectives (see Fig. 1.1):

1. **To understand the effects on student behavioral engagement of reward-based strategies in real MOOC contexts.**

   In many cases, reward-based strategies have been effective in promoting student engagement and retention in different educational environments including online and blended learning. However, the distinctive features of MOOCs (*e.g.*, the massive number of heterogeneous students unknown by practitioners during the design of the courses), and the lack of empirical evidence of the impact of reward-based strategies in MOOCs hinder the use and adoption of these strategies in such massive contexts. Therefore, the first main contribution of this thesis (*CONT#_STU*) consists on **three empirical studies performed in real MOOC environments analyzing the effect of reward-based strategies on student behavioral engagement** [207, 206]. The gamification of these three studies was co-designed between the instructors of the courses and the researchers to analyze the gamification capabilities

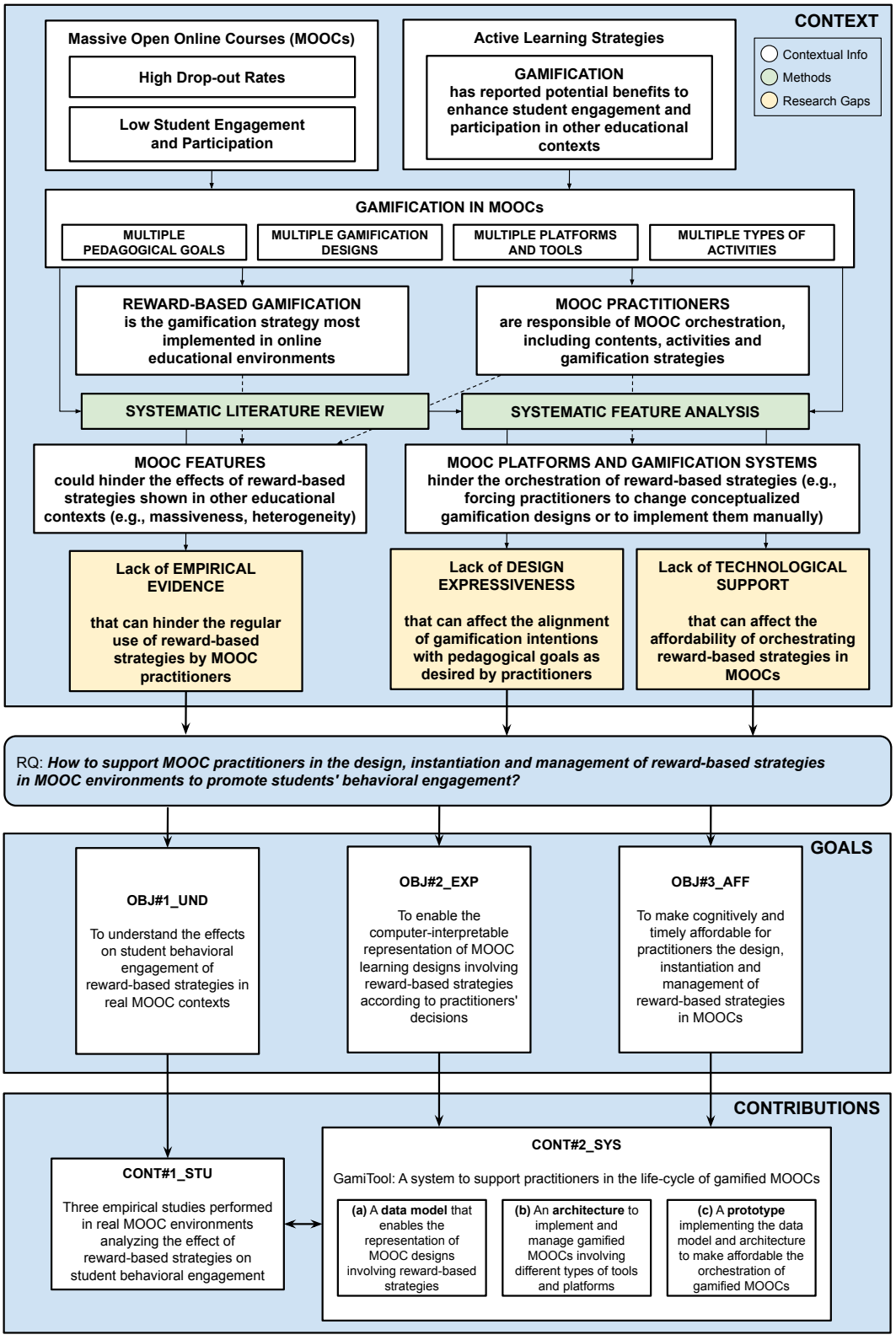


Figure 1.1: General dissertation schema including the context, research question, goals and contributions.

of the implemented systems, and to align the course pedagogical goals with the reward-based strategies. These analyses aim to understand the effect of reward-based strategies on student behavioral engagement, and to motivate the usefulness of technological systems supporting the use of these strategies in MOOC environments.

2. **To enable the computer-interpretable representation of MOOC learning designs involving reward-based strategies according to practitioners' decisions.**

   As mentioned before, the massive number of enrolled students and the continuous activity in these courses call for automatic methods for managing reward-based strategies. The computer-interpretable representation of reward-based strategies in MOOCs is presented as a potential solution for the automatic intervention of digital systems connecting with MOOC platforms. Additionally, this digital representation would allow to reuse successful gamification designs in other MOOCs. However, the current support for representing reward-based strategies within MOOCs is limited. The existing solutions have a limited expressiveness and do not allow the design and configuration rewards and condition logics at a fine-grained detail, thus restricting in some cases the student behaviors that practitioners want to promote with gamification (*i.e.*, gamification purposes [14, 13]), and their alignment with the course pedagogical goals. Therefore, one of the main contributions of this dissertation is the proposition and evaluation of **a data model that allows the computer-interpretable representation of MOOC learning designs involving reward-based strategies with a fine-grain detail of expressiveness in the rewards and completion logics**. This data model should be able to support the representation of MOOC learning designs involving rewards that have been effective in promoting student behavioral engagement disregarding the course topic and platform.

3. **To make cognitively and timely affordable for practitioners the design, instantiation and management of reward-based strategies in MOOCs.**

   As stated before, the design, implementation and management of gamification-related activities imply an extra work (time and effort) [69] added to the existing work employed by practitioners to produce and orchestrate a MOOC. This extra work can suppose a limitation in the use and adoption of these strategies in MOOC environments. Therefore, another main contribution of this dissertation is **a system that allows practitioners the affordable design, instantiation and management of reward-based strategies in MOOCs** [208]. This system will implement the aforementioned data model to allow the digital representation of reward-based strategies with a fine-grain reward and completion logic. Since during the last years there has not been a predominant MOOC platform [254, 255, 257], the proposed system should be able to provide solutions to multiple MOOC platforms to reach a broader number of potential practitioners interested on applying reward-based strategies into their courses.

1.3 Research Methodology

The successful attainment of the aforementioned objectives requires the selection of an adequate research methodology. A methodology defines *"the assumptions and values that serve as a rationale for research and the standards or criteria the researcher uses for interpreting data and reaching a conclusion"* [20]. The selection of a research methodology is usually guided by the research discipline including the research questions and objectives, and the psychological underpinnings of the researcher [94]. Accordingly, one of the first considerations that researchers should face before conducting a research process is the definition of how the world is understood and studied [135, 241], *i.e.*, the *worldview* [53] or *paradigm* [155]. Creswell and Poth (2017) [53] and Mertens (2014) [181] identified four predominant worldviews differing in the form this world is conceived (*i.e., ontology*), and the form the knowledge is created (*i.e., epistemology*): post-positivism, social constructivism, transformative paradigm (advocacy/participatory) and pragmatism.

My personal form of understanding the world tends to be deterministic (*i.e.*, every event is determined by previous existing causes and conditions) and therefore, more aligned with the *post-positivism* worldview. According to this worldview, there exist a single reality which can be only known imperfectly and probabilistically, due to multiple factors such as the human context, background, culture, genes, etc. [236]. Additionally, this worldview grounds its epistemology in the objective generation of knowledge and in the generalization of results [241].

This approach fits well when addressing *exact sciences* such as physics or chemistry since most of the variables (causes and conditions) are known and controllable. However, during this PhD I learned that in the case of *social sciences* there is such a large number and unknown parameters affecting human behavior, that knowledge creation in *social sciences* is sometimes not addressable from this approach. Therefore, although this single reality can be described in terms of probabilities based on multiple social factors (*e.g.*, background), qualitative methods and subjective interpretations (*e.g.*, observations, open-answers in questionnaires) are also needed to contextualize the reality, to perceive the inner state of humans (*e.g.*, thoughts, feelings) and to further understand the reasons for such probabilities. Thus, in this dissertation we consider the existence of a reality that can be interpreted differently by individuals due to social factors, and whose knowledge can be obtained through different approaches and methods depending on the research aim and context. This form of conceiving the world and building knowledge is consequently more aligned with the *pragmatism* worldview [181]. According to this worldview, research needs to be contextualized, and knowledge is obtained using both quantitative and qualitative methods according to the research purposes, focusing on its practical implications [241].

As exposed before, this dissertation is framed into a multidisciplinary domain where the design and development of conceptual and technological contributions are expected to have an impact in the educational field. Therefore, we explored several TEL-research frequent methodologies such as the Engineering Method [1, 100], Design-Based Research [229, 275], the Design Science Research Methodology [214, 126], and the System Development Research Methodology [201]. Finally, the System Design Research Methodology (SDRM) was selected as the most appropriate methodology for this dissertation due to the

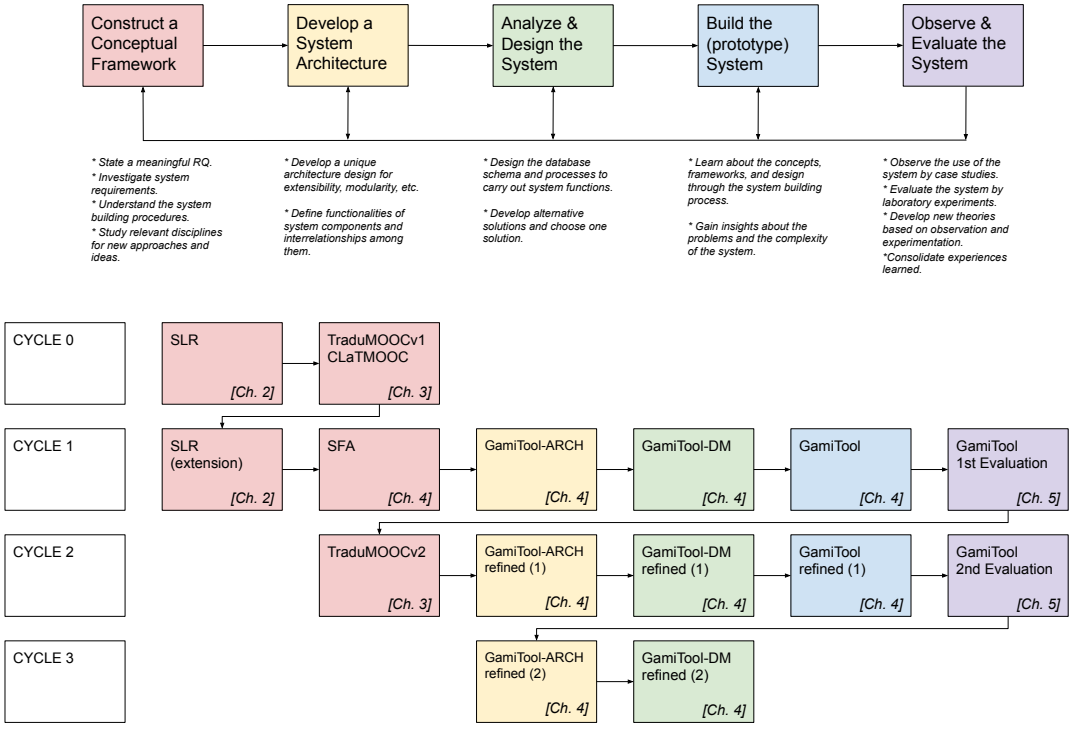


Figure 1.2: Life cycle of the System Design Research Methodology [201] (top), and the research process followed during this dissertation, including the relationship with the chapters of this dissertation (bottom).

following reasons.

SDRM combines research issues typically observed in the social (behavioral) and in the engineering (software development) fields, research areas directly connected with the goals of this dissertation. Additionally, SDRM is an appropriate methodology in which the development of systems represents an important contribution during the research process. In this context, the overarching objectives of this thesis, *i.e.*, the understanding of students behavior within gamified MOOC environments, and the affordable orchestration of reward-based strategies through the development of technological and conceptual contributions, are completely aligned with the purposes for which this methodology was designed to, making it very suitable to achieve them. Finally, SDRM involves an iterative process so that the experiences and knowledge gained during the research process can help refine the contributions. Therefore, this iterative process can potentially contribute to the refinement of such contributions, and to better understand their real impact on practitioners.

SDRM organizes research into an iterative five-stage methodological process [201]. The five methodological stages defined for SDRM, and their application in this dissertation are described as follows (see Fig. 1.2):

1. **Construct a conceptual framework.** During this phase, researchers state a meaningful RQ, investigate system requirements and relevant disciplines for new approaches and ideas [201]. To this end, during the first methodological cycle (*Cycle*

0), we performed a Systematic Literature Review (SLR) [148] which helped us identify: (i) a lack of empirical studies performed in real MOOC environments, and (ii) a lack of gamification systems supporting the orchestration of reward-based strategies in MOOCs. The first limitation, led us to perform three empirical studies (*CONT#1_STU*) to understand practitioners' needs, platform constraints and the effects of gamification on student engagement during *Cycle 0* (TraduMOOCv1, CLaTMOOC) and *Cycle 2* (TraduMOOCv2).

The outcomes obtained from the studies performed during the first cycle (*i.e.*, literature review and empirical studies) led us to identify a set of features and requirements that would support the orchestration of reward-based strategies in MOOCs. According to this dissertation goals, the features were classified into three categories: design expressiveness, practitioners' affordability and adoption, and positive learners' experiences. In order to understand the extent to which current gamification systems and MOOC platforms provide support to such features, during *Cycle 1* we performed a Systematic Feature Analysis (SFA) [149]. Results showed important limitations for the three identified categories, helping us refine and propose this dissertation's main research question.

2. **Develop a system architecture.** The next phase of the SDRM methodology involves the development of a unique architecture design supporting the required functionalities [201]. System architecture provides a road map for the system building process, specifying the system functionalities, and defining the structural relationships and dynamic interactions among the system components [201].

   Given the context of this dissertation, once we identified the limitations of current gamification systems through the SFA, a first sketch of the expected system was designed (*Cycle 1*). The proposed system architecture (*GamiTool-ARCH*) aimed at supporting the features intended to increase practitioners' affordability and adoption of reward-based strategies in MOOCs (*CONT#2_SYSb*). This contribution was iteratively refined throughout the different cycles we carried out.

3. **Analyze and design the system.** This stage involves the design of the envisioned system including user interfaces, data structures and databases [201]. Additionally, this phase can serve to define alternative solutions to help identify the most suitable for the research purpose.

   At this stage, a computer-interpretable model (*GamiTool-DM*) was proposed during *Cycle 1* to help overcome those limitations related to design expressiveness of current systems (*CONT#2_SYSa*). This data model served as the basics of the database implemented in the envisioned system, being both of them iteratively refined throughout (*Cycle 2* and *Cycle 3*). During this stage, we also decided to create a prototype following specific software design guidelines to complete those features associated with the usability of the system.

4. **Build the (prototype) system.** This phase involves the development of a system prototype: GamiTool (*CONT#2_SYSc*). The system prototype served (1) to complete the requirements identified as important to support practitioners' affordability

and adoption and to promote positive learners' experiences; (2) to demonstrate the feasibility of the proposals (*i.e.*, GamiTool-DM, GamiTool-ARCH and GamiTool prototype); and, (3) to evaluate their functionality in real world settings. The development of the prototype helped to complete some of the identified system requirements which could not be addressed by the proposed data model and architecture. Also, during the development process, the design of the interfaces and database was refined according to the used technologies and to the evaluations performed during the first and second cycle.

5. **Observe and evaluate the system.** During this phase, researchers (1) test the system performance and usability, (2) validate the degree of system support to the defined requirements, and (3) observe their impact on individuals [201]. Given this context, the first evaluation iteration (*Cycle 1*) involved one practitioner who tested the initial version of the prototype in a real MOOC (TraduMOOCv2), helping to gain insights about the system features and the refinement of the proposals. In the next iteration (*Cycle 2*), a set of 19 MOOC practitioners and/or gamification designers from multiple institutions evaluated the system, providing valuable insights that enable us to assess positively the achievement of the related dissertation goals. The input provided by the evaluation participants also helped to refine the system and to define future research goals.

1.4 Document Structure

This dissertation is organized as follows (see Fig. 1.3).

Chapter 2 delves into the theoretical background of the thesis research context. This research context involves the main ideas behind (i) MOOCs, including their differences with other educational environments, their benefits and their current drawbacks; (ii) gamification in education, including the differences with other similar concepts, theoretical models used for gamification design and associated orchestration tasks; and, (iii) the current state and limitations of gamification strategies in MOOC environments obtained through a systematic literature review.

Chapter 3 presents the first contribution of this dissertation (*CONT#1_STU*), three empirical studies performed in three different MOOCs to understand the effects of reward-based strategies on student behavioral engagement. The first two studies implemented a set of badges whose conditions were associated to different types of activities, providing evidence about participants' perceptions and about the relation between participants' behavioral and reward-derived engagement. The third study describes a between-subjects design study in which MOOC participants were randomly assigned to different conditions to better understand the effect of different reward-based strategies on student behavioral engagement and course attrition rates. Conclusions and potential design guidelines derived from these studies are outlined at the end of this chapter.

Chapter 4 extends the literature review about gamification in MOOCs with a systematic feature analysis to grasp the level of support of current MOOC platforms and gamification systems to the orchestration of reward-based strategies in such massive contexts. The chapter describes and motivates the features considered for this analysis, and the limitations found regarding the design expressiveness and affordable use of these strategies. Furthermore, the chapter also expose the second contribution of this dissertation (*CONT#2_SYS*) aiming to help overcome the aforementioned limitations: a system to support practitioners in the orchestration of gamified MOOCs. The different components of such system are also presented in this chapter: *(a)* a data model, *(b)* a system architecture, and *(c)* a developed prototype.

Chapter 5 exposes the two evaluation studies of the second contribution, performed with MOOC practitioners and gamification designers. The first study involved a MOOC instructor who used the developed prototype to design, instantiate and manage reward-based strategies within her course. The second study entailed nineteen practitioners who created their own gamification designs and used the prototype to design and instantiate a given gamified MOOC. The results gathered and the level of accomplishment of this dissertation goal are discussed at the end of this chapter.

Chapter 6 draws the conclusions of this dissertation, highlighting the implications and relevance of this work in the educational research area. This chapter also points out future lines of research emerged from the work performed within the context of this dissertation.

Finally, the appendices include supplementary material, including: the evaluation questionnaires used during the empirical studies to measure MOOC participants' perceptions toward reward-based strategies (Appendix A); the questionnaire template (*i.e.*, score sheet) used during the systematic feature analysis (Appendix B); the list of resource types, action types, rule types and privilege types supported by the proposed data model (Appendix C); a set of screenshots of the last version of the developed prototype (Appendix D); and, the evaluation worksheet used during the second evaluation study of the developed prototype (Appendix E).

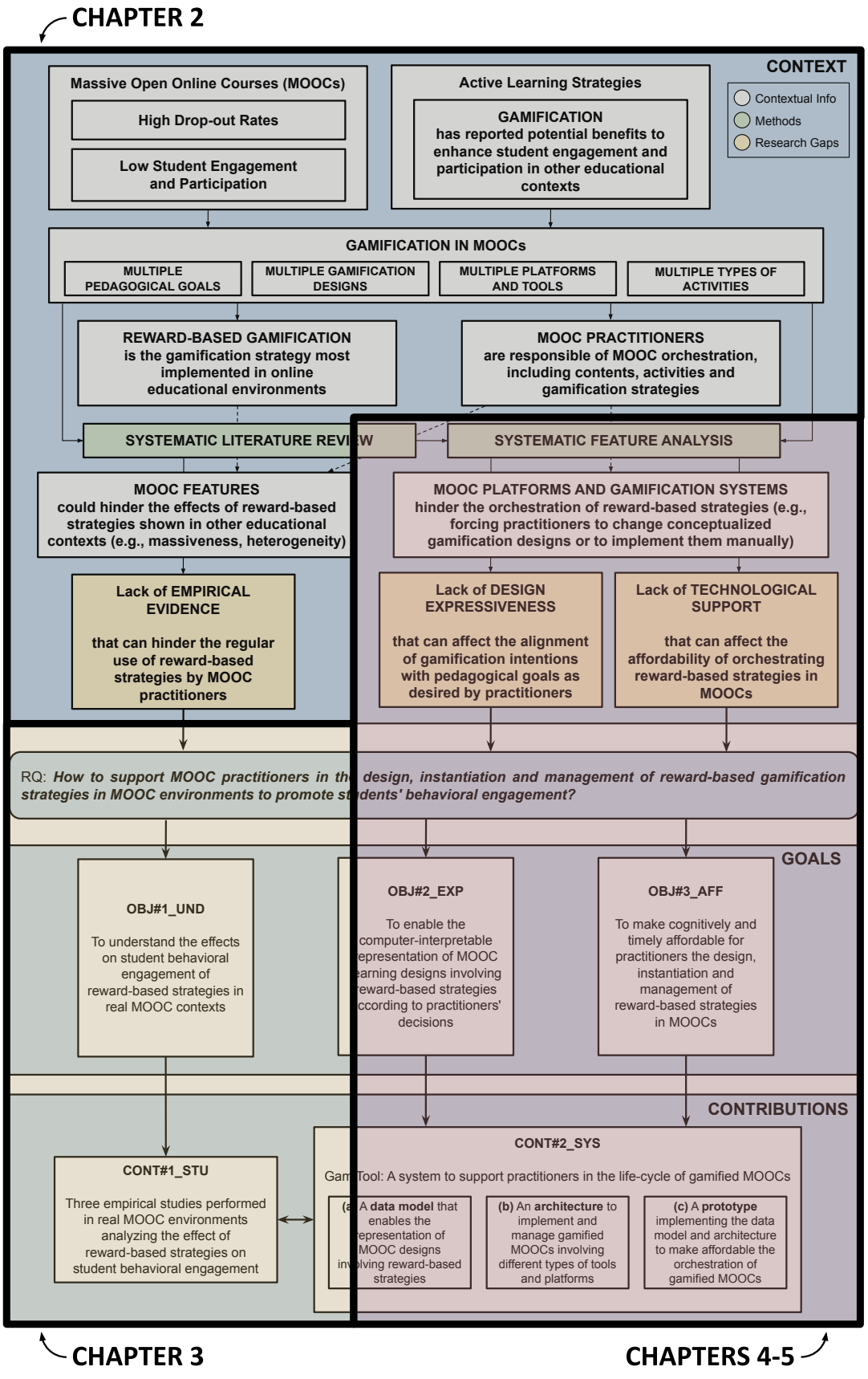


Figure 1.3: Document structure according to the general dissertation schema.

Chapter 2

Research Context: Reward-Based Strategies in MOOCs

Summary: This chapter introduces the context of this dissertation, focusing on the problems identified in the previous chapter. First, the chapter summarizes the current landscape of **MOOCs**, including their peculiarities, benefits and drawbacks. One of the main drawbacks identified in the literature is the lack of student engagement, leading to course abandonment, which could potentially be addressed with gamification strategies. Accordingly, the concept of **gamification** and **reward-based gamification** are introduced together with their theoretical background, and their implications for practitioners during the different phases of gamified learning situations. Then, we focus on **gamification in MOOCs**, describing the peculiarities of these courses that can hinder the extrapolation of the gamification benefits observed in other domains and educational contexts (*e.g.*, blended learning). In order to shed light on the implications of such MOOC peculiarities in the gamification effects, we report on a **systematic literature review** regarding the use of gamification strategies in MOOC environments. Results show that despite the increasing number of studies addressing gamification in MOOCs, there is a **scarcity of empirical studies performed in real MOOC contexts**, thus lacking evidence of the actual effects of reward-based strategies on MOOC participants. The main problems identified in the literature review and the proposed solutions to address them are also discussed.

2.1 Introduction

The main goal of the Technology-Enhanced Learning (TEL) research domain is to facilitate and improve teaching and learning practices by means of technology [22, 81]. This chapter introduces the main pillars of this dissertation which are framed within the wide area of TEL: **MOOCs** [73] and **gamification** [111]. Both research topics have been widely explored in the literature separately. However, the combination of both areas opens new challenges and research possibilities which are also summarized in this chapter (see Fig. 2.1).

The venue of MOOCs opened up a number of benefits for the educational community (*e.g.*, open and free access to courses from prestigious universities) [264, 88, 64].

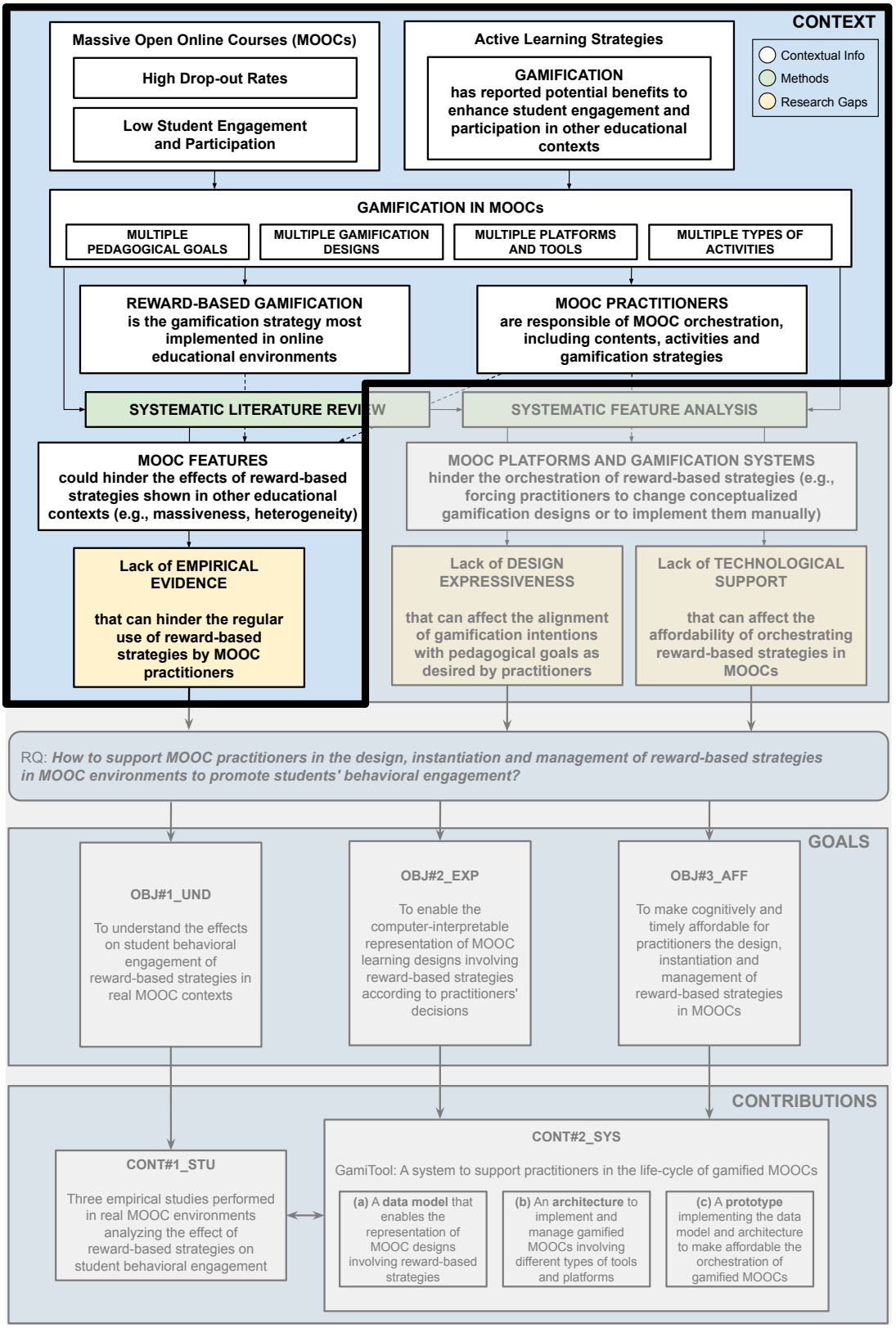


Figure 2.1: Research context schema of this dissertation.

However, MOOC specific features (*e.g.*, massive number and heterogeneous students, asynchronous interactions, need for automated tools) pose several challenges to keep students engaged within the learning contents and activities throughout the whole course [140, 128]. This dissertation proposes the use of gamification (more concretely, reward-based strategies) to help overcome MOOC engagement problems, based on the benefits shown in other educational environments (*e.g.*, small-scale online courses) [61, 111, 67]. To help understand the context of this dissertation, Section 2.2 exposes the origin of MOOCs, their peculiarities as compared with other forms of teaching and learning, and the identified drawbacks of these courses. Additionally, Section 2.3 introduces the concepts of 'gamification' and 'reward-based strategies', the theoretical underpinning of these strategies on learners' behavior, and their implications for practitioners.

Nevertheless, it is worth mentioning that the aforementioned MOOC distinctive features can potentially have an impact on the positive effects observed on student engagement in such different educational environments (see Section 2.4). Consequently, we propose the realization of a systematic literature review to understand the current landscape of the use of gamification strategies in MOOC environments and to gather evidence about its potential benefits (see Section 2.5). Results revealed two important limitations which are proposed to be addressed in this dissertation: (1) a lack of empirical evidence regarding the effects of reward-based strategies in MOOC contexts, and (2) a lack of technological systems supporting the orchestration of these strategies (see Fig. 2.1).

2.2 MOOCs

MOOCs have been established as a widespread form of global education that combines structured classroom-based tools (*e.g.*, slides, questionnaires) with online tools and resources (*e.g.*, videos, social networks) [264, 73]. The *MOOC* term was originally coined in 2008 by Dave Cormier and Brian Alexander at the *Connectivism and Connective Knowledge* conference whose organizer was George Siemens [204]. During the same year, George Siemens and Stephen Downes launched the first online open course named as 'MOOC', entitled as the conference name: "Connectivism and Connective Knowledge" [79, 264]. This course was translated into six different languages and registered approximately 2,200 participants [264]. Some years later, 2012 was considered as 'the MOOC year' due to the increasing number of courses provided under this same approach [213]. But, what are the distinctive features of MOOCs to make them different from other forms of education?

- **[M]assive:** The 'massive' term refers to the unlimited number of course enrollments permitting the registration of hundreds of thousands of students in the same course [35]. Consequently, this high number of enrollments usually forces MOOC practitioners to have a low or non-existent interaction with course participants [35]. There is not a common agreement in the minimum number of enrollments to consider a course as *massive* [264]. However, the review of MOOCs performed by [134] shows that MOOC enrollment usually range from 300 to more than 225k students.

- **[O]pen:** The 'open' term regards that any person with Internet access is eligible to participate in the course without admission process. Due to the evolution of MOOC business models, some MOOC platforms permit the free access to the course contents and activities although course completion certificates could be charged with monetary fees (*e.g.*, Coursera[1]), and can require the realization of a previous course or paid tuition [35]. Given this context, non-public courses (*e.g.*, courses with admission process) are referred as 'private' instead of 'open' (*e.g.*, Small Private Open Courses or SPOCs) [193].

- **[O]nline:** The 'online' term refers to the form in which course contents and activities are offered [264]. The online format forces MOOC practitioners to provide digital learning contents (*e.g.*, videos, online readings and presentations), and to evaluate students through auto-graded quizzes and peer-feedback assignments [35], as compared with other forms of learning such as the face-to-face or blended approaches. This format also forces practitioners to use online private messages (*e.g.*, via email) and discussion forums to promote interaction between course participants.

- **[C]ourse:** The 'course' term refers to complete educational experiences following a pedagogical approach in which resources and learning activities are sequentially structured [264, 168]. Differently from Open Educational Resources (OERs) and the Open Course Ware project, MOOCs involve resources and learning activities structured in multiple modules and following a concrete pedagogical approach [168]. Attending to the schedule and pace to complete the course activities and materials, MOOCs are classified into *instructor-led* and *self-paced*. While learning resources and assignments become available at specific times in the instructor-led modality, all course materials and assignments are available at the beginning of the course without due dates in the self-paced modality [85].

All these distinctive features (*e.g.*, lower fees, flexible schedule, open and unlimited enrollment) make MOOCs different as compared with other forms of learning (*e.g.*, blended-courses, OERs, SPOCs) [257].

Originally, MOOCs were categorized into *cMOOCs* and *xMOOCs* according to two different pedagogical approaches applied in such courses [264, 103, 73, 273]. On the one hand, cMOOCs (*connectivist MOOCs*) [131] are courses encouraging participants to generate and share the content knowledge [103]. This type of courses are based on a high interaction between course participants and between practitioners with participants [73]. Additionally, these courses are typically poorly structured and highly decoupled, implementing tools for peer interaction such as discussion forums and peer reviews. Accordingly, cMOOCs are usually aligned with the connectivism pedagogical approach [80].

On the other hand, xMOOCs (*extended MOOCs*) [131] are courses where practitioners are the only source of reliable knowledge. Practitioners are responsible for preparing and uploading the course contents (*e.g.*, video lectures, activities, assessments). Participants visualize the contents and complete the activities without the requirement of interacting

[1]Coursera: *https://www.coursera.org/*, last access: September 2020.

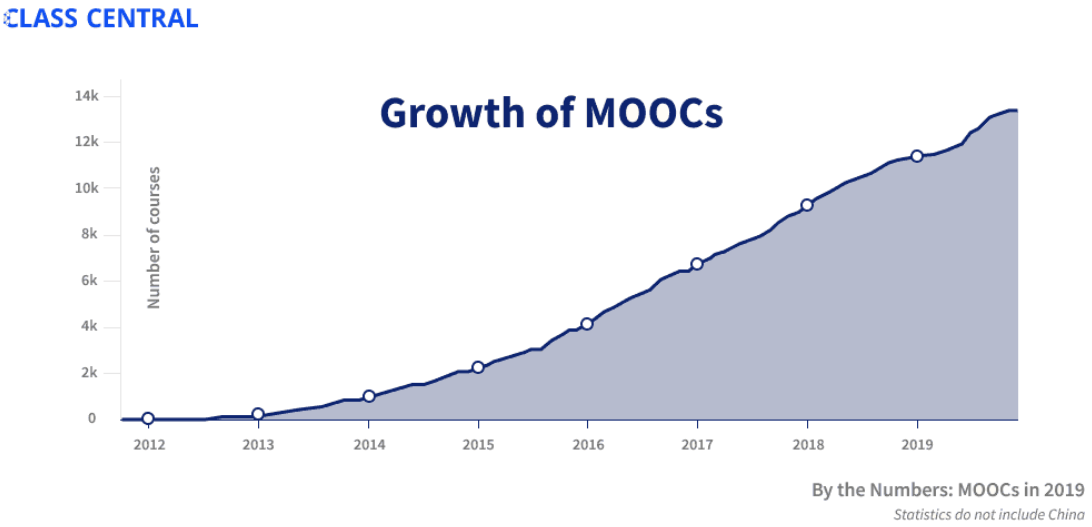


Figure 2.2: Growth in the number of global MOOCs [258].

with other participants to acquire knowledge. In this type of courses, participants are eligible to obtain a course completion certificate once the compulsory activities are completed successfully. Accordingly, xMOOCs are usually aligned with the behaviorism pedagogical approach [145]. While early MOOCs tended to follow the cMOOC model, recent MOOCs follow the xMOOC approach (courses offered in mainstream platforms such as Coursera and edX) [282]. Nevertheless, it is worth mentioning that both models share the aforementioned distinctive features of MOOCs and use similar learning tools (*e.g.*, video lectures, documents, discussion forums) [282].

The high impact of MOOCs in current society can be shown in terms of statistics. Although there is a slowdown in the growth of new users and the number of courses offered in the last years [258, 230], nowadays more than 900 universities have offered MOOCs in at least 35 different MOOC platforms [259]. Currently there are more than 110M students enrolled in, at least, one of the 13.5k MOOCs that have been offered since the first official MOOC in 2008 (see Figure 2.2) [258]. Additionally, apart from the existing well-known MOOC platforms such as Coursera[2], EdX[3], or Canvas Network[4], some national governments are funding country-specific MOOC platforms such as MéxicoX[5] (Mexico) and ThaiMOOC[6] (Thailand), thus socially promoting this form of learning [259]. Another sign of the high impact of MOOCs is the creation of degrees and bachelors from prestigious universities, following the MOOC teaching model (*e.g.*, MicroMasters, Nanodegrees) [35]. In consequence, the impact and proliferation of MOOCs leads to new research opportunities to facilitate better learning opportunities for both practitioners and students [273, 283].

MOOCs have brought important benefits to the educational community such as the

[2]Coursera: *https://www.coursera.org/*, last access: September 2020.
[3]EdX: *https://www.edx.org/*, last access: September 2020.
[4]Canvas Network: *https://www.canvas.net/*, last access: September 2020.
[5]MéxicoX: *https://www.mexicox.gob.mx/*, last access: September 2020.
[6]ThaiMOOC: *https://thaimooc.org/*, last access: September 2020.

democratization of education, free access to structured education from prestigious universities, the creation of communities around a shared topic, etc. [264, 88, 64]. The main reasons for MOOC student enrollment are usually associated to the desire to learn new topics and extend the current knowledge, and to personal interests (*e.g.*, self-challenge, attainment of completion certificates) [128, 260]. Besides, universities have found in MOOCs a way of reusing teaching and learning materials used in face-to-face and blended courses, and a form of external promotion. However, despite these positive aspects, MOOCs present some important drawbacks pointed out by both researchers and practitioners. Among the most important drawbacks, we can highlight the following two:

a. **Limited pedagogical quality and limitation of mass teaching methods** [178, 239, 139, 128]. A systematic analysis of 76 MOOCs (cMOOCs and xMOOCs) concluded that the instructional design quality of MOOCs is low, lacking among other pedagogical approaches, expert feedback, personalized learning, collaborative learning, and knowledge application [178]. Also, the literature review performed by [128] pointed a set of drawbacks of current MOOC pedagogical approaches including the lack of interactivity between course participants (*i.e.*, practitioners and students) and the lack of learners' support. These constraints are likely to create feelings of isolation on participants, limiting their knowledge acquisition and contributing to disengage from the courses. Furthermore, the literature review also pointed to the limited forms of participants' assessment (*i.e.*, automatic questionnaires and peer evaluations). The massive number of enrolled students, the heavy demands of time for MOOC orchestration, and the need of automatic tools in this type of courses pose important challenges for practitioners and researchers to help overcome this drawback.

b. **Lack of student motivation and engagement to complete course activities leading to high drop out rates** [140, 260, 133, 3, 82, 128]. Researchers have identified different learners' profiles enrolling in MOOCs attending to their behavior in the course [150, 4, 87, 169]. While some profiles refer to students that enrolled in the course without visiting the learning contents and/or participating in course activities (*e.g.*, *no shows*, *observers* [4]), some other profiles (*e.g.*, *returners*, *midway dropouts* [88]) refer to students that initially showed interest and motivation to complete the course but at certain point, they stopped interacting with the course contents and activities. According to [88], these type of learners can account up to 35% of the enrolled students, number that can represent thousands of students in the MOOC context. This student disengagement can potentially lead to course abandonment, thus contributing to the high drop out rates identified in these courses and whose average completion rate is around 15% [134].

Given this context, gamification is proposed as a potential strategy to help overcome these MOOC drawbacks [59], due to the promising results reported in other educational environments (*e.g.*, face-to-face, blended learning) [61, 67].

2.3 Gamification in Education

Nowadays, games are statistically the most popular form of entertainment as compared with TV, movies and music [77][203]. Games' entertainment has its roots on the human feelings (*e.g.*, excitement, curiosity, fun, competition) that game elements are able to generate as part of the interaction with the players [90]. The term *serious game* was coined to define those games whose main purpose is different than the mere entertainment (*e.g.*, education, wellness) [184]. More concretely, those serious games whose main purpose is pedagogical are named *educational games* [152, 277], generating the so-called *Game-Based Learning (GBL)* [221]. Although there is a broad research body on GBL [60, 225], educational games present several important challenges that hinder their use and adoption [60, 218], such as difficulties on the educational assessment or the affordability and effectiveness of designing digital games for specific educational purposes. In this context, there is a similar approach that tries to replicate the benefits of games (*e.g.*, increase user's engagement) by adapting game elements to non-recreational contexts: *gamification*.

2.3.1 Origins of Gamification

Gamification was originally defined in 2002 by Nick Pelling as *"putting together the game design elements (i.e., competitiveness, targets, rewards and recognitions) in everyday business activities"* [177, 262]. However, it was in 2010 when the term *gamification* started to be generally adopted, being used in commercial platforms [38], conferences [281], books [285], and integrated into the *2011 Gartner's Hype Cycle* for emerging technologies, and for education [159, 172]. One year layer, in 2011, *gamification* was redefined to include its use and application in other environments as *"the use of game design elements in non-game contexts (e.g., business, wellness)"* [65], thus including the educational environment [157], and gaining widespread acceptance [61].

Game design elements are the resources (*e.g.*, loyalty points) and techniques (*e.g.*, engagement loops) used in digital games able to motivate the users, hold their interest and/or challenge them to solve problems [265, 61]. The aim of gamification designers is to identify such elements, and adapt them according to the purposes for their inclusion (*e.g.*, increase loyalty) and the application context (*e.g.*, environment, topic, users' profile) [265]. With the purpose of supporting the design of gamified scenarios, multiple authors have proposed frameworks categorizing game design elements into different levels of abstraction [205, 186]. In this context, one of the most popular gamification categorizations in the literature is Kapp's classification [137].

This classification distinguishes between *content* and *structural* gamification. The former classification refers to those situations that involve the explicit creation, or the edition of already-designed activities to make them more game-like (*e.g.*, contents, goals). Game design elements such as virtual worlds (*e.g.*, Minecraft virtual world [263]), game-like interfaces (*e.g.*, LEGO theme [274]) and narrative stories [18] are usually aligned with this type of gamification. The latter classification involves those situations in which game design elements are added "around" the contents and activities without the need of large structural modifications. Game design elements such as mini-games [154, 216], rewards (*e.g.*, badges [8]) and social elements (*e.g.*, leaderboards [188], votes [113]) are frequently

associated to this type of gamification. While *content gamifications* can potentially result into activities more similar to digital games, and consequently, potentially attractive for users, content creation and adaptation in *structural gamifications* usually involve less workload for gamification designers [205].

2.3.2 Reward-Based Gamification

According to previous literature reviews on gamification [111, 67], rewards are the game elements most used in educational contexts, generating the so-called *reward-based gamification* [200] or *incentive systems* [156]. Reward-based gamifications can be defined as those strategies that define game design elements (*i.e.*, rewards) integrating a *signifier* (*e.g.*, name, visual, description) that are issued once a predefined *completion logic* (*i.e.*, conditions defined beforehand) is satisfied [110, 109]. Examples of reward-based strategies in educational environments frequently involve the attainment of: achievement badges issued when students complete course tasks under specific conditions (*e.g.*, before a deadline, without errors) [108, 77, 130, 96, 74, 219], karma points and votes issued by course peers (*e.g.*, reputation in discussion forums) [42, 197], or leveling up when a certain number of points is reached [202, 129]. Additionally, sometimes, reward-based gamificaitons incorporate leaderboards listing course participants according to either the number of rewards earned (*e.g.*, points, badges) [77, 130, 202], or to their performance when completing a course task (*e.g.*, grades, time) [96, 212], thus promoting the social comparison between course peers [89].

Reward-based gamifications have raised up some controversy by academics and gamification designers [253]. Some critics refer to the use of the word 'gamification' to denote this type of gamification. Criticizers argue that rewards are the least important elements of games, which are only used to display game outcomes rather than having an impact on the gameplay [235, 47]. Robertson (2010) [235] explains that rewards are powerful motivators that deserve to be studied and adapted to other contexts but they should be renamed to avoid misconfusion with games. Consequently, terms such as 'pointsification' [235] and 'exploitationware' [30] have been proposed to denote the use of reward-based strategies. In this dissertation, we have explicitly referred to these techniques as 'reward-based strategies', trying to make clear the distinction between the general concept of gamification and this concrete type of gamification.

Some academics have also criticized these strategies because they replace real incentives with the mere attainment of fictional rewards [62, 30, 47]. Chorney (2012) [47] remarks that these fictional rewards can engage and provide instant feedback to users but lack valuable content as slot machines do. It is worth considering that these critics were founded in the marketing and business fields (*e.g.*, commercial apps) where the main purpose of reward-based strategies is to make economical and marketing profit [253].

These critics can be partly transferred to the educational domain where the main goal (*i.e.*, learning) can be replaced by extrinsic rewards (*e.g.*, earn points). From this point of view, initial learners' motivation to enroll in a course can be substituted by the attainment of such fictional rewards, also contributing to potential negative behaviors such as cheating or trial-and-error behaviors. However, it is worth considering that differently from the business and marketing domain, gamification in the educational context aims to

achieve student benefits (*e.g.*, increase engagement, increase participation) without any economical or marketing benefit for the designer. Thus, considering the previous comparison, while the design purpose of slot machines is to keep users engaged inserting coins (random condition whose performance produce an economical benefit for the designer), reward-based strategies in education aim to engage students to keep interacting with the learning contents and activities by known and achievable conditions that potentially produce positive side-effects on student learning.

After several years of research, academics and practitioners have identified several reasons behind the attainment of rewards in learning environments such as intrinsic and extrinsic motivation [200], sense of progression and goal accomplishment [109] or simply fun [50]. These reasons (*i.e.*, behavioral drivers) have been shown to be effective in the attainment of potentially useful learners' benefits (*e.g.*, increase student engagement, increase learning outcomes, promote student socialization) in different educational environments as following described.

Hakulinen et al. (2013) [108] gamified an online environment for learning "data structures and algorithms" with badges whose attainment did not alter students' final grade. Badge conditions were associated to time management (*e.g.*, succesfully complete a round of exercises, at least one week before the deadline), carefulness (*e.g.*, complete a round of exercises without mistakes at first attempt) and learning (*e.g.*, do all exercises correctly twice). A between-subjects design study showed the positive impact of badges on early task submission, avoid trial and error submissions, and on learning outcomes (*i.e.*, better course grades), as compared with the control group (without badges). Results also suggested that some implemented badges did not induce the expected positive effect on students.

Domínguez et al. (2013) [77] carried out a between-subjects design study in a virtual learning environment (BlackBoard) for an undergraduate blended-learning course about "qualification for users of ICT". The gamification design included (a) medals and trophies issued for participating and successfully completing challenges/activities, and (b) a public leaderboard ranking students according to the number of challenges successfully completed. Results showed significant higher initial motivation, and better scores in practical assignments when comparing the experimental condition with the control group (without gamification). Results also showed that students from the experimental condition obtained lower scores in the written assignment and participated less on class activities.

Ibáñez et al. (2014) [130] performed a case study about the effects of reward-based strategies in a platform used for a C-programming learning course taken by undergraduate engineering students. Similarly to previous studies, the gamification design involved different types of rewards (*e.g.*, points, badges) issued when mastering different C-programming language concepts and activities, and a leaderboard displaying those students with most rewards. Results showed positive effects on student engagement toward the gamified learning activities. Additionally, students kept on doing course tasks after completing the compulsory activities because some students wanted to earn all badges, wanted to reach better positions on the leaderboard, and wanted to increase their knowledge.

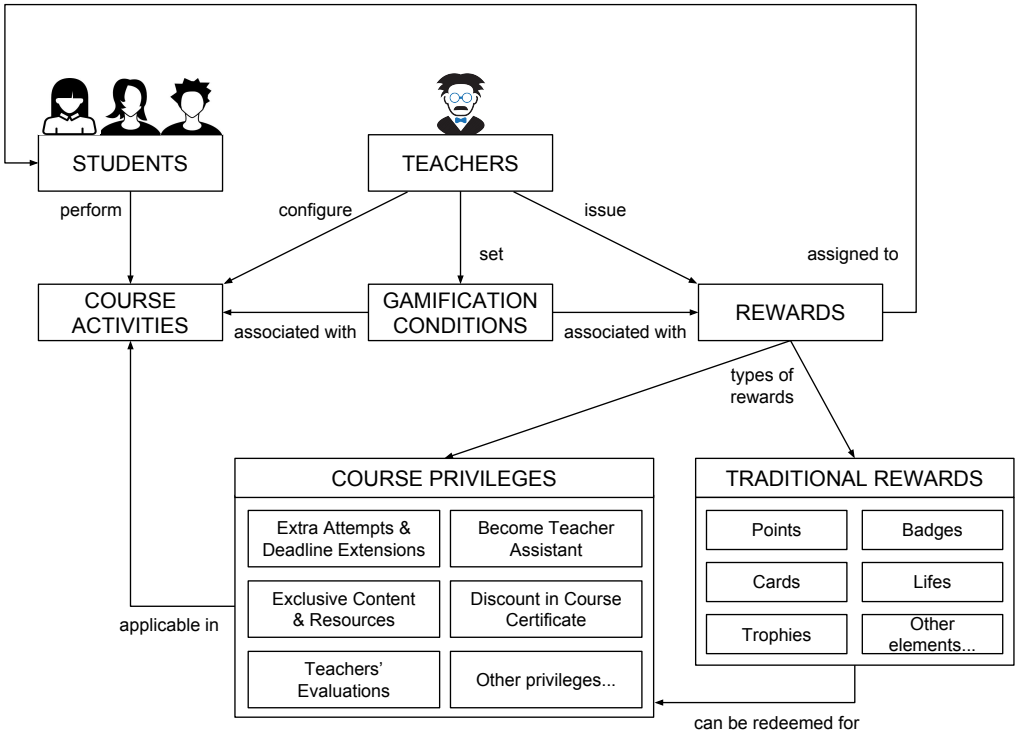


Figure 2.3: Conceptualization of reward-based strategies [208].

2.3.3 Traditional Rewards vs. Course Privileges

Many games incorporate game design elements that can be redeemed for unlocking or buying contents and objects (*e.g.*, new figures, weapons, stages). Utilizing rewards in such a way can further enhance players' motivation and engagement due to the possibility of achieving such new elements, and using them to progress and perform better in the game. This same idea has been transferred to gamification in educational contexts by rewarding students with course-related privileges aiming to increase learners' motivation and engagement [202, 208]. Some examples of course-related privileges are access to exclusive videos and submissions, unlock extra or exclusive learning contents, provide students with extra attempts and/or more time to perform course quizzes, extend the due date of course assignments, access to exclusive evaluations performed by teachers, etc.

In a traditional reward-based gamification (see Fig. 2.3), *teachers* configure *course activities*, and set *gamification conditions* under which the *rewards* will be issued to the *students* [208]. When incorporating course-related privileges (*i.e.*, course privileges), these privileges can be directly rewarded to students when satisfying the predefined conditions, or can be redeemed when a pre-established number of traditional rewards is reached. For instance, students accumulating virtual currency (traditional reward) can access to the "course shop" to redeem such virtual cash for getting a deadline extension in the upcoming course submission (course privilege). Differently from traditional rewards, course privileges are meaningful rewards that have a real impact on students' learning and engagement [70, 208]. This real impact can be the main reason why these elements have been identified as more engaging than traditional rewards in online environments [43, 234].

The following experimental studies confirmed the potentiality of using course privileges in different educational contexts.

Dicheva et al. (2019) [70] gamified an undergraduate course about data structures with badges, virtual currency that could be redeemed for course privileges, and a leaderboard to encourage students' self-study and engage them with out-of-class online practicing. Results showed a statistically significant increased out-of-class practicing and a reduced failing rate as compared with a previous run of the same non-gamified version of the course (control group).

Odonovan et al. (2013) [202] implemented a content-and-structural gamification on a university course about game development with points that could be redeemed for course privileges, badges, progress bars, and a leaderboard. Similarly to the previous study, results showed a statistically significant improvement of course grades as compared with the scores obtained in the previous non-gamification version of the course (control group).

Rizzardini et al. (2016) [234] gamified a 5-week MOOC entitled "Authoring tools for e-learning courses" with badges, leaderboards, and templates useful for the authoring tools taught during the course (course privilege). According to authors, the gamified strategies did not increase student engagement but authoring-tool templates were reported to motivate the completion of course activities higher than leaderboards and badges.

Given this context, reward-based strategies including both traditional rewards and course privileges are presented as potential strategies to help increase student engagement in online educational environments.

2.3.4 Main Psychological Theories Related to Gamification

There exists the popular belief about the effectiveness of gamification grounded in the assumption that games are fun and engaging [111]. However, recent studies have shown that gamification can also derive into student negative effects such as undesired competition, off-task behavior, or fading interest [199, 9, 114]. Although there are numerous studies about the effects of gamification [61, 67, 41], there is a lack of understanding about how gamification (reward types, completion logic, etc.) should be applied to obtain the expected benefits on students. Literature has reported several theories from the psychology field aiming to understand how game design elements are capable to modify human behavior [113, 144]. Two of these theories have been repeatedly used to achieve learning benefits with game design elements: the *Self-Determination Theory* (SDT) [63, 244], and the *Flow Theory* [58, 57].

The SDT is a macro theory that defines inherent growth tendencies and innate psychological needs affecting to human motivation and personality integration [244]. These innate psychological needs are: (1) *Autonomy*: The human sense of self-governance or ruled by oneself [245]; (2) *Competence*: The notion of perceiving oneself to be effective [63]; and (3) *Relatedness*: The feeling of needing relationships characterized by both regular contact and ongoing connection [27]. Depending on the level of satisfaction of these three needs, the human motivational state can range from *amotivation* to *intrinsic motivation*. Being intrinsically motivated within a task, humans are able to enhance their performance, persistence, creativity and self esteem in such task [244]. Therefore, gamification strategies targeting such three psychological needs (challenge students, make them

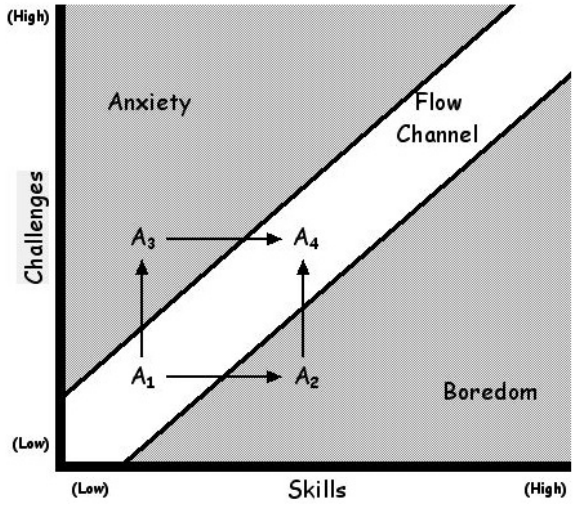


Figure 2.4: Flow theory representation [56].

feel competent, and connect with course peers) can potentially be used as motivators to engage learners with course contents and activities [269].

Another psychological theory connecting human motivation with engagement and behavior is the Flow Theory. According to Czikszentmihaly (2000), *flow* is defined as *"a state of absorption in one's work characterized by intense concentration, loss of self awareness, a feeling of being perfectly challenged and a sense that time is flying"* [57]. The most important condition to reach the flow state is to find the proper balance between personal capabilities and the goals and challenges established. Too complex tasks will generate frustration and anxiety, losing interest and engagement on such activity. While improving capabilities, challenges need to be updated according to students' knowledge and capabilities to keep the flow state throughout the whole course (see Fig. 2.4). Thus, gamifications must balance learners' capabilities and knowledge keeping learners motivated and engaged during the attainment of the established goals and challenges through the attainment of rewards and their associated conditions.

Therefore, practitioners should precisely design their gamified learning situations attending to these psychological motivators by aligning them with the expected gamification outcomes to be promoted and with the game strategies implemented. However, the use of gamification strategies in educational environments implies many other tasks that need to be considered conveniently for the attainment of the expected gamification benefits.

2.3.5 Lifecycle of Gamified Learning Situations

So far, we have seen the potentialities of reward-based strategies (and of gamification in a broader sense) to produce benefits for students in educational contexts. However, what implications do the use of these strategies have for practitioners? When practitioners decide to use game design elements in their learning situations (*i.e.*, gamified learning situations), they need to carefully design them and perform a set of gamification-related tasks in order to attain the expected gamification benefits. From a temporal perspective, we can define a life-cycle of gamified learning situations identifying the main tasks and

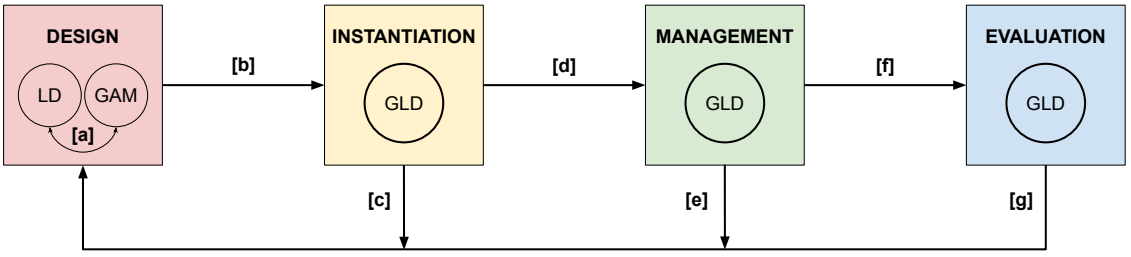


Figure 2.5: Lifecycle of gamified learning situations.

phases involved from the conceptualization of the gamification to the evaluation of the produced effects. Thus, the definition of this life-cycle can help understand practitioners' involvement when using gamification strategies in learning environments.

In this context, literature has reported multiple phases that should be considered for creating meaningful gamified learning experiences [125, 90, 119, 118, 183, 10]. Nevertheless, the lack of common agreement in the number of phases, in its terminology and in the practitioners' associated tasks poses difficulties to define a common agreed life-cycle. For the purposes of this dissertation, and with the aim of structuring practitioners' associated tasks and classifying the existing works about gamification, we propose four generic phases under which the tasks described in the previous related works are included. The four generic phases are inspired in similar research works whose main goal is the incorporation of active learning strategies in pedagogical situations such as those involving Computer-Supported Collaborative Learning [237]. These generic phases are: design, instantiation, management and evaluation of the learning situation (see Fig. 2.5).

Design

In non-gamified learning situations, the design phase aims to define the learning situation components (*e.g.*, resources, activity sequence) and goals [237]. This definition can be computationally represented by using existing learning design languages (*i.e.*, *learning design* approach), or directly in the tools that will be used during the enactment of the learning situation (*i.e.*, *bricolage* approach) [122, 223]. One of the most known learning design languages is IMS-LD[7]. Differently from the *bricolage* approach, computer-interpretable languages enable the automation of processes during the deployment of learning situations in virtual and distributed learning environments (*e.g.*, Moodle, Google Documents) [224].

In gamified situations, apart from the definition of the learning design components, practitioners are also responsible for deciding the gamification purposes (*e.g.* foster participation, increase learning outcomes), selecting the most suitable game design elements (*e.g.*, narrative, rewards) and configuring their relationship with the learning design components (*e.g.*, conditions under which rewards will be issued) [183, 10]. For both approaches, decisions regarding gamification may have an impact in the learning design and vice-versa (see transition *[a]* in Fig. 2.5).

[7]IMS Global Learning Consortium: *http://www.imsglobal.org/learningdesign/index.html*, last access: September 2020.

Previous studies in the literature have proposed multiple design frameworks in order to guide practitioners during the gamification design phase [186]. Similarly, some other research works focus on facilitating decision making during the design process. For instance, Antonaci et al. (2018) [10] carried out a study with gamification designers and TEL experts to understand which game design elements and patterns can better accomplish specific gamification purposes (*i.e.*, increase student goal achievement, learning performance and student engagement) in MOOC environments.

Similarly to learning designs, gamified designs need to be digitally represented to support automation during the deployment and execution of gamified learning situations. In this situation, learning designs incorporating gamification strategies must be represented with digital languages able to translate the aforementioned decisions to computer-interpretable designs. Some researchers have proposed computer-interpretable languages for gamified learning designs. For instance, Lipczynski et al. (2017) [165] presented an adaptation of orchestration graphs [72] to include gamification decisions into learning designs (*e.g.*, skip a lecture if student successfully completed a set of quizzes). Limitations and restrictions of computer-interpretable languages for gamified situations will hinder the game design elements used, the connections with the learning design components and the gamification purposes that could be promoted. Therefore, computer-interpretable languages need to provide enough expressiveness and flexibility to allow practitioners represent and automate their gamification design decisions.

Instantiation

In non-gamified scenarios, once implicit and explicit learning designs are finished (transition *[b]* in Fig. 2.5), practitioners are responsible for setting up the learning components (*e.g.*, resources, tools, groups, dates) into the learning environments (*e.g.*, classroom, Moodle) that will be used during the learning situation [237]. In gamified scenarios, practitioners are also responsible for setting up the game design elements and their interaction with the learning components and environments. For example, Moodle plugins[8] enable practitioners to set up different types of gamified activities within their courses.

During this stage, practitioners may become aware of limitations in the learning environments and the gamification systems that would hinder the digital implementation of the envisioned gamified learning designs (GLDs). Given this situation, platform constraints can force practitioners to use different game design elements and to re-design the GLDs (see transition *[c]* in Fig. 2.5). For instance, taking back the previous example, current Moodle plugins do not support the integration of course privileges within the Moodle course activities (except unlocking extra content). Platform constraints should be devised during the design phase to understand the capabilities of the environments that will be used in the learning situation to avoid changes in the implementation of GLDs [10]. At the end of this phase, participants of the gamified learning situation should be able to start using the tools and environments configured to this end (see transition *[d]* in Fig. 2.5).

Previous studies have reported research studies dealing with the deployment of gamified learning situations and its affordability for practitioners. For instance, Hansch et al.

[8]Gamification Moodle Plugins: *https://moodle.org/plugins/?q=gamification*, last access: September 2020.

(2015) [113] performed an empirical review of online learning platforms to understand the type of game design elements supported by each platform. Also, Domínguez et al. (2013) [77] investigated the effects of gamification strategies in a blended learning university course through experimental design. Authors reported that the gamification plugin used hindered the gamification design due to its limitation to track student actions in external software. Therefore, course designers were forced to adapt the GLD: students had to take screenshots of the completed activities, and upload them in the gamified learning management system (*i.e.*, Blackboard[9]). Additionally, since the gamification plugin was not able to distinguish whether screenshots showed the expected results, rewards were given to all students uploading a file without verifying if the task was successfully accomplished.

Management

This phase begins once the learning activities start. In non-gamified contexts, practitioners' tasks may involve (i) run-time management of the learning activities (*e.g.*, provision of resources at certain moment, changes in group composition); and (ii) monitoring student actions within the deployed learning design components and environments (*e.g.*, certain students are not participating in the group debate) [237]. In this context, learning analytics provide practitioners with useful information (specially in large-scale contexts with complex tasks) to understand whether learning activities are achieving their learning purpose, and if necessary, redesign such activities [252]. In gamified learning scenarios, monitoring student actions within the game elements can help understand unexpected behaviors and provide useful information to redesign the GLD if needed (see transition *[e]* in Fig. 2.5) [118]. Analogously to learning analytics, the concept of gamification analytics has been defined as *"the data-driven processes of monitoring and adapting gamification designs"* [118]. The most relevant *gamification metrics* identified by Heilbrunn et al. (2017) [118] are *gamification feedback rate*, *point distributions*, *achievable gamification elements* and *detailed gamification element statistics* (*e.g.*, time to complete the reward-condition).

Additionally, the concrete case of reward-based gamifications involves, during this phase, an additional set of sequential sub-events associated to the run-time management of gamification strategies:

1. **Triggering:** This event defines the condition under which the reward-issuing procedure will be initiated. This event can be manually started by students (*e.g.*, pressing a button to claim the reward) [55], by practitioners (*e.g.*, after the practical sessions) [96], and/or automatically supported by technological systems (*e.g.*, right after completing a course task) [242].

2. **Data Collection:** In order to understand whether reward-conditions have been successfully satisfied by students, practitioners need to collect all indicators associated to the condition itself (*e.g.*, the number of completed tasks). This information can be either provided by students while initiating the triggering event [55], manually collected by practitioners [96], and/or automatically supported by technological systems [242].

[9]Blackboard: *https://www.blackboard.com/*, last access: January 2020.

3. **Data Processing:** The information gathered in the *data collection* event needs to be processed to decide the feedback given to students according to the configured GLD. For instance, practitioners may compare the number of completed challenges for a concrete student with the threshold configured in the GLD to decide whether issue the associated badge.

4. **Informing:** This event involves the notification of the *data processing* outcome. This happening can be omitted (*e.g.*, if the conditions were not satisfied), can be presented in the form of messages (*e.g.*, tips for achieving the associated reward) and/or can include the reward itself (*e.g.*, a badge).

5. **Data Recording:** *Data collection* and *data processing* outcomes may be stored for multiple purposes such as avoiding issuing the same reward twice, list the earned rewards in a leaderboard or providing gamification analytics to support the monitoring of the GLD.

Although these events are carried out during course enactment, practitioners should define and configure them during the design phase. Usually, in virtual learning environments, these sub-events are performed by gamification systems in which practitioners need to explicitly represent their design decisions. Limitations in the design and configuration of these events (*e.g.*, the system cannot track specific student actions associated to the *data collection* happening) can lead to restrictions in the GLD. Therefore, the selection of the gamification system becomes an important decision for the implementation and management of desired GLDs.

Evaluation

In this phase, practitioners revise and refine the outcomes of the learning situation once it is finished (see transition *[f]* in Fig. 2.5). Course indicators and practitioners' perception can provide useful insights to refine the enacted LD for future activities and learning scenarios. In gamified scenarios, the focus of this phase may lie on analyzing and understanding the effects of the implemented gamification strategies considering the design purposes for which gamification was applied [90, 10]. Given this context, practitioners can analyze whether the gamification purposes were achieved, if the game elements affected to the development of the learning tasks or if some game elements were more effective than others. Therefore, the GLD can be further enhanced for future gamified activities and designs (see transition *[g]* in Fig. 2.5) to achieve the intentions pursued with the gamification (*e.g.*, higher engagement, funnier experience, better learning outcomes).

Previous studies have reported research works dealing with the implications of gamified learning situations in the re-design of future scenarios. For instance, Staubitz et al. (2017) [267] examined and redesigned the initial considerations taken for the design of gamification in the OpenHPI[10] platform based on data collected from a set of empirical evaluations. Among other modifications, authors reduced the amount of experience points (XPs) issued for submitting tests from 10XPs to 2XPs (for the 90% first correct submissions) to adapt the XPs to task difficulty.

[10]OpenHPI: *https://open.hpi.de/*, last access: January 2020.

2.4 Gamification in MOOCs

Previous studies have shown the benefits of using gamification in multiple learning environments to improve learners' motivation [77, 90], engagement [75, 96, 130, 202], learning outcomes [77, 130], and enjoyment [90], among other purposes. Therefore, considering such positive effects, gamification could help overcome some of the aforementioned limitations of MOOCs such as the low student engagement and participation (see Sec. 2.2). Nevertheless, MOOCs present specific features different from other educational environments (*e.g.*, face to face or blended courses) which may have significant implications in how reward-based strategies are designed, instantiated and managed (see Sec. 2.2). This section summarizes the most potential implications of such features in the life-cycle of gamified MOOCs:

1. The open and massive nature of MOOCs usually lead to a broad variety in participants' background, knowledge, learning culture and goals, as opposed to the limited diversity in formal education settings where teachers can more easily recognize their students' characteristics and goals. Therefore, MOOC practitioners can potentially face difficulties to design reward conditions that sufficiently challenge and engage a varying learner population without leading to the states of either boredom (over-simple) or anxiety (over-challenging) [57].

2. The massive number of participants and the online nature on MOOCs restrict the learning contents (*e.g.*, videos, online readings and presentations), activities and evaluation tools (*e.g.*, auto-graded quizzes, peer-feedback assignments) that are frequently implemented in these courses [35]. Therefore, the results obtained in previous successful GLDs involving resources and tools that cannot be implemented in MOOCs cannot be extrapolated and such designs would need to be redesigned.

3. People tend to evaluate their abilities by comparing them with the abilities of others [89]. Previous studies incorporating game elements that can be compared by participants (*e.g.*, badges listed in a leaderboard), showed that such comparison usually reduces users' performance rather than enhance it [278]. Although this drawback was already observed in other gamified educational contexts, the openness and massiveness of MOOCs are likely to increase the heterogeneity (*e.g.*, interest on badges, previous knowledge) and the differences among students' player profiles [26]. These larger differences can lead to demotivation when comparing others' achievements in those students avoiding external rewards or with difficulties to earn them.

4. As a result of the massiveness, there is a need for implementing automatic rewarding approaches in MOOCs since practitioners cannot track participant actions individually and they cannot timely issue badges manually [77, 96]. Therefore, the predefined conditions under which the rewards are issued are restricted to the students' actions that can be tracked by MOOC platforms and integrated gamification systems. Additionally, in small-scale contexts, practitioners can typically cope with the workload of manually assessing the quality of the student actions, thus opening the possibility of designing conditions based on such quality-related aspects of the

actions (*e.g.*, correctly answering to a peer question). However, in MOOC contexts, practitioners are unlikely to manually assess the quality of students' outcomes due to the massive number of participants. Therefore, automatic methods considering natural language processing or peer evaluation replace the manual evaluation of quality-related actions.

Attending to the previous MOOC specific features, the extrapolation of the gamification benefits reported in other educational environments should not be taken for granted and need to be studied. In this situation, a Systematic Literature Review (SLR) about gamification in MOOCs could help identify how these strategies are being designed, instantiated and evaluated and the current research gaps in which this dissertation can be framed.

2.5 Systematic Literature Review of Gamification in MOOCs

Existing literature reviews regarding MOOCs [168][131][140][273] do not focus on the extent to which games, game elements or gamification strategies are being used in such contexts. Additionally, existing literature reviews about gamification [61][111][41][67][66] are generally focused on small-scale environments, thus covering a very limited number of studies about the use of gamification in MOOCs. At this moment, two systematic reviews dealing with the use of gamification in MOOCs have been reported in the literature [144, 11]. However, the review performed by Khalil et al. (2018) [144] covers a very limited number of studies (18) published before November 2017, and the review performed by Antonaci et al. (2019) [11] is restricted to empirical studies in the general context of online courses (27). This section presents a systematic literature review including theoretical, conceptual and empirical studies dealing with gamification in MOOCs until April, 2019. This literature review aims to shed some light about the current use of gamification in MOOC environments, and to identify potential research gaps to be addressed within this dissertation.

2.5.1 Research Questions

In order to guide this process, the SLR has been framed into four different research questions (RQs) following an anticipatory data reduction process[11] [185]. The proposed RQs have been further subdivided into more concrete informative questions to deepen in the SLR analysis and get precise results and conclusions about the current state of gamification in MOOCs (see Fig. 2.6):

- **RQ1: What is the current state of research on gamification in MOOCs?** This questions aims to understand what types of works (*e.g.*, theoretical proposal, prototype development, empirical study) and publications (*e.g.*, journal, conference proceedings, technical report) are most frequent in literature. Such classifications can help understand what is the current overall state of gamification in MOOCs.

[11] According to Miles and Huberman (1994) [185], data reduction refers to *the process of selecting, focusing, abstracting and transforming the data that appear in written-up fields notes or transcriptions*. This data is advised to be divided into topics and subtopics at different levels of analysis deciding the conceptual framework, cases, research questions and data collection approaches to choose [185].

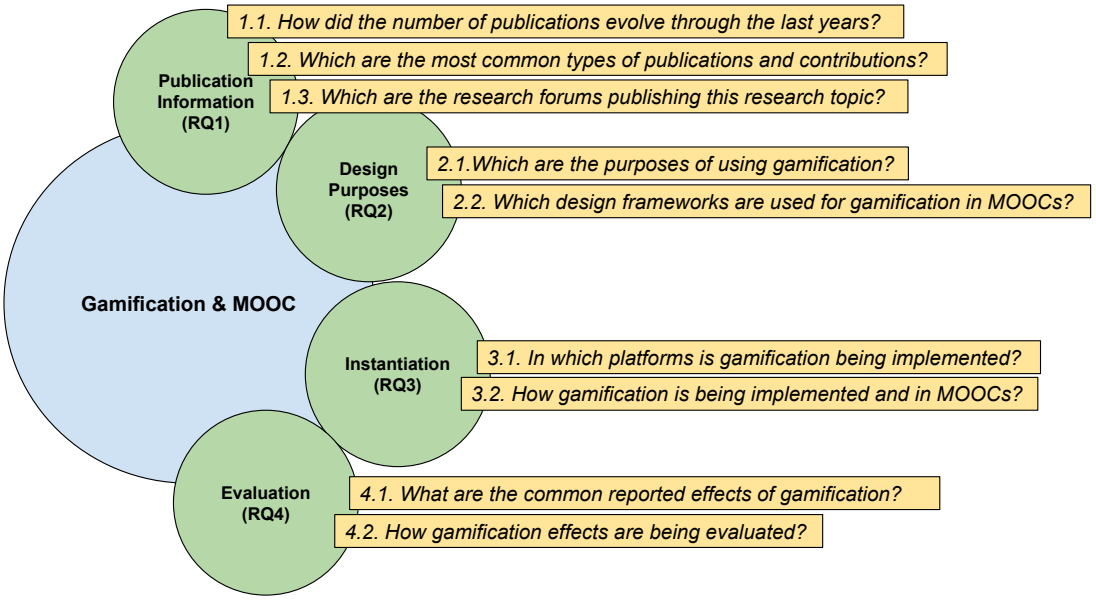


Figure 2.6: Anticipated research design including the research topics (circles) and informative questions (rectangles) guiding the systematic literature review.

- **RQ2: Which are the designed purposes of using gamification in MOOCs?** Gamification has been included in other educational contexts with different purposes such as increasing the students' learning outcomes, enhancing the students' motivation, engagement and interaction, driving the students' behavior, promoting the students' active learning, etc. This question aims to analyze which are the design purposes and pedagogical intentions of using gamification strategies in MOOC environments, and if such purposes are similar to those presented in other educational contexts.

- **RQ3: How gamification is being implemented and managed in MOOCs?** The application of different types of gamification depends on the tools and platforms used for implementing and managing gamification strategies in MOOCs. This questions aims to get an overview of the current tendencies of gamification in MOOCs, including the used platforms, the game design elements, and the conditions associated to student actions frequently implemented in gamified scenarios.

- **RQ4: What are the reported effects of using gamification in MOOCs?** The effects of gamification hardly depends on the learning design context (*e.g.*, course topic, participants' background, tools used) [271]. This question aims to understand which are the reported effects of empirical studies about gamification in MOOCs and how these effects are being evaluated.

2.5.2 Methodology

In order to answer the aforementioned RQs, we followed the guidelines proposed by Kitchenham & Charters (2007) [148] to perform SLR in the software engineering area.

This methodology has been used in previous surveys in the area of technology-enhanced learning [102, 248], structuring the SLR in three phases (*i.e.*, planning, conducting and reporting) providing guidelines on how to conduct each of them [148]. Table 2.1 presents a summary of the decisions taken during the planning phase.

The selected bibliographic databases were ACM Digital Library (Guide to Computing Literature)[12], IEEE Xplore Digital Library[13], ScienceDirect[14], Scopus[15], and Springer Link[16]. These databases were considered as the most relevant in the topic field and were also used in previous literature reviews dealing with gamification in educational environments [61, 111, 41, 67, 66, 144].

The proposed search string was *<gamif*> AND <*MOOC*>*[17]. This string allows to find publications including deviations of the gamification term such as *gamified* or *gamify* and with deviations of the MOOC term such as *cMOOC* or *MOOCs*. The search string was searched in the title, abstract or keywords (abstract only when database presented search restrictions) of journal publications, conference proceedings, books, book chapters, technical reports and thesis, thus avoiding possible bias by articles reporting only positive results. The search has not been restricted to any time period due to the recent coinage of both *gamification* and *MOOC* terms, *i.e.*, 2008 and 2002 respectively (coined year) [168][177]. Besides, both terms are currently getting growing research interest [273][67]. A first SLR was carried out in 2017 including manuscripts published before April 2017 as reported in Ortega-Arranz et al. (2017) [210]. In 2019, the SLR was extended by applying the same methodology, extending the time range until April 2019. As a result, a total number of 370 publications were retrieved in the extended review. Retrieved publications were then filtered according to one inclusion and three exclusion criteria aiming to precisely answer the proposed RQs:

I1. Gamification in MOOCs must be a central topic of the manuscript. Publications discussing the potential use of gamification in MOOCs but evaluating the effects in other similar environments such as online courses or SPOCs are also included in this criterion (being classified as *MOOC-like empirical studies*). On the other hand, publications proposing as a future work the use of gamification strategies to keep students engaged in MOOCs are excluded from this survey.

E1. Conference, workshop, book and chapter summaries or prefaces.

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.

The inclusion and exclusion criteria were applied by reading publications' title and abstract, and if there were still doubts, the full document. Afterwards, duplicates retrieved

[12] ACM Digital Library: *https://dl.acm.org/*, last access: January 2020.
[13] IEEE Xplore Digital Library: *https://ieeexplore.ieee.org/*, last access: January 2020.
[14] ScienceDirect (Elsevier): *https://www.sciencedirect.com/*, last access: January 2020.
[15] Scopus (Elsevier): *https://www.scopus.com/*, last access: January 2020.
[16] Springer Link: *https://link.springer.com/*, last access: January 2020.
[17] In those databases restricting the use of '*' for advanced search, the search string was replaced by <gamification> AND <MOOC>.

Parameter	Decision	Reason
Databases	ACM Digital Library, IEEE Xplore, Digital Library, Science Direct, Scopus, and Springer Link.	We believe that these databases are the most relevant databases in the topic field. Additionally, these databases have been previously considered for literature reviews about gamification in education [61, 41, 71].
Search string	"gamif*" and "*MOOC*" ("gamification" and "MOOC" if restriction).	We aim to find publications about gamification in MOOCs including derivations of the gamification term such as 'gamified' or 'gamify' and with derivations of the MOOC term such as cMOOC or MOOCs.
Search location	Title, abstract and keywords (metadata or abstract if restriction).	We believe that publications describing gamification in MOOC environments will mention the terms *gamification* and *MOOC* in the title, abstract and/or keywords.
Time restrictions	No time restrictions (until April 2019).	We aim to consider all published documents disregarding the time of publication.
Screening	By reading title and abstract first, then, if needed, the body text.	We believe that publications considering gamification in MOOC environments will summarize their main contributions in the title and abstract, providing enough information to apply the inclusion and exclusion criteria.
Inclusion criteria	[I1] Gamification in MOOCs must be a central topic of the manuscript.	This analysis aims to investigate publications whose main purpose is the use of gamification strategies in MOOC contexts.
Exclusion criteria	[E1] Conference, workshop, book and chapter summaries or prefaces. [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.	The analysis of publications considering other purposes different than gamifying online learning situations are out of the goal of this feature analysis.

Table 2.1: Decisions taken during the SLR planning phase.

	ACM	IEEE Xplore	Science-Direct	Scopus	Springer Link	TOTAL
Search location	abstract	metadata	metadata*	metadata*	no restrict.	
Retrieved publications	20	35	6	130	188	370
Screening based on Inclusion and exclusion criteria	7	19	2	52	15	95
Duplicates	(7)	(18)	(2)	(37)	(12)	-19
Snowball references						+13
Total						**69**

Table 2.2: Overview of the systematic literature review process (*due to database search restrictions, metadata information included title, abstract and keywords).

from different databases were removed (39 publications). Additionally, topic-related publications cited in the accepted manuscripts and satisfying the inclusion and exclusion criteria (snowball references) were also considered (13 publications). As a result, a total number of 69 publications were included in this review (see Table 2.2).

2.5.3 RQ1. Distribution and Type of Publications

Gamification in MOOCs started to gain importance in 2012 through the use of badges [54]. The emergence of the Open Badges project (originally called Mozilla Open Badges project)[18] boosted the usage of open badges as a way of recognizing and sharing students' actions in online learning environments [55]. However, the first publications about gamification in MOOCs as a central topic date from 2014. Publications have been categorized attending to the publication venue (see Fig. 2.7) and contribution (see Fig. 2.8). Results show:

- There is a slow increase in the number of publications from 2014 to 2017, reaching the highest peak in 2017 with 21 publications. 2018 experienced a strong downfall of publications that seemed to recover again in 2019 (note that the literature review is limited to April 2019).

- Most papers are published in conferences (71.01%) far followed by JCR-indexed journals (11.59%), non-JCR-indexed journals (7.25%), book chapters (7.25%), discussion papers (1.45%) and master thesis (1.45%). In the last years, there is an increasing number of publications in journals (80% of the total publications in 2019) as compared to the decrease in the number of conference publications. Yet, the number of publications in journals is low, suggesting that research on gamification in MOOCs is starting to be considered as an important topic inside the TEL area but still needs to grow up.

[18] Open Badges project: *https://openbadges.org/*, last access: January 2020.

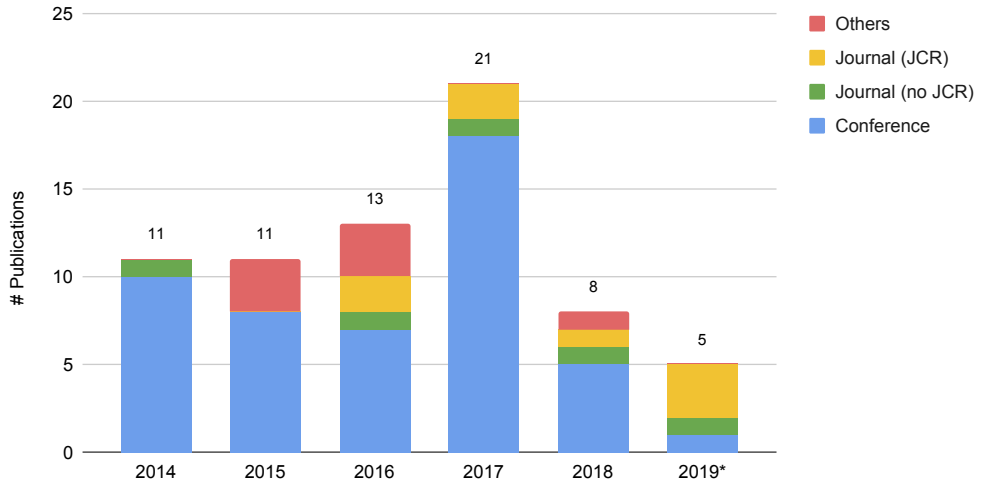


Figure 2.7: Distribution of publications included in the literature review attending to the year of publication and publication type (2019* until April).

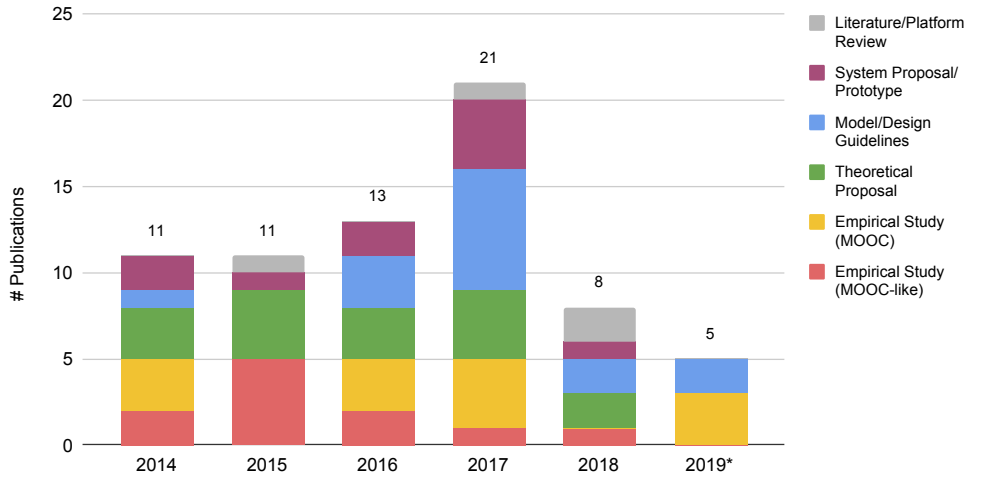


Figure 2.8: Distribution of publications included in the literature review attending to the year of publication and type of contribution (2019* until April).

- The forums where gamification in MOOC research is often published are: eMOOCs[19] (6) , EDUCON[20] (4), EC-TEL[21] (2), ECGBL[22] (2) , GALA[23] (2), MiTE[24] (2), TEEM[25] (2) and EITT[26] (2).

[19] European MOOCs Stakeholders Summit.
[20] IEEE Global Engineering Education Conference.
[21] European Conference on Technology-Enhanced Learning.
[22] European Conference on Game-Based Learning.
[23] Games And Learning Alliance Conference.
[24] International Conference on Mobile Technology in Teacher Education.
[25] International Conference on Technological Ecosystems for Enhancing Multiculturality.
[26] International Conference on Educational Innovation Through Technology.

- *Theoretical proposals* are the most frequent type of contribution (23.19%), followed by *models/design guidelines* (21.74%), *empirical studies (MOOC)* (18.84%), *empirical studies (MOOC-like)* (15.94%), *system proposals/prototypes* (14.49%), and *literature/platform reviews* (5.80%). According to these results, 60.87% publications describe *theoretical proposals*, *conceptual models* and *empirical studies performed in different contexts than MOOCs*, showing that, theoretically, gamification is a common agreed solution for MOOCs. However, the low number of empirical studies performed in real MOOC environments (13) and gamification systems (5) as compared with the high number of MOOCs and MOOC platforms, indicates the premature stage of this research area.

According to this analysis, gamification in MOOCs seems to be in a premature stage due to the increasing number of publications, the increasing number of journal publications and the low number of empirical studies performed in real scenarios. Therefore, it seems necessary to provide more empirical evidence in real MOOC contexts to understand the effects of different gamification strategies in MOOCs and provide useful guidelines to effectively implement it as pointed out by Khalil et al. (2018) [144].

2.5.4 RQ2. Gamification Design Purposes in MOOCs

Many gamification design purposes have been reported in the literature [144]. Results gathered in Table 2.3 show that the most repeated gamification design purposes in MOOCs are: increase student engagement (*e.g.*, complete more activities and modules), student motivation/retention (*e.g.*, feel motivated to finish the course), promote student interactions (*e.g.*, posts in discussion forums) and increase students performance (*e.g.*, get better scores). Other design purposes have been theoretically proposed but scarcely applied in conceptual models and empirical studies such as improve assignments' quality [187], show course progress [48], improve learners' self-regulation [271], on-board students within the MOOC environment [179] or distribute platform usage times [279]. These results support and expand the gamification design purposes (*i.e.*, reasons) identified in the literature review performed by Khalil et al. (2018) [144] in which *enhance motivation and engagement* were the most repeated reasons identified for using gamification in MOOCs.

Although multiple gamification design purposes have been identified in the different empirical studies performed in real MOOC environments, only three studies report the use of existing theoretical frameworks to achieve the expected gamification purposes. Rizzardini et al. (2016) [234] used the *Attrition Model for Open Learning Environments Settings (AMOES)* [105], a model that relates attrition and retention factors in open learning environments (*e.g.*, MOOC organization) to different learner profiles. Romero-Rodríguez et al. (2019) [240] followed the principles proposed by Llorens-Largo et al. (2016) [170] to design gamified learning scenarios. Finally, Khalil et al. (2017) [143] reported the use of the *Activity-Motivation Framework* [142]. This framework proposes the accomplishment of four dimensions to keep students motivated with MOOCs: logins in the platform, interaction with course videos, quiz submissions and participation in discussion forums.

Therefore, despite the increasing number publications describing models and design guidelines for gamification in MOOCs, only three *empirical studies* actually used design

Design Purpose	Theoretical proposals	Model & Guidelines	Empirical studies (MOOC)
Increase student engagement	[261, 136, 187, 92, 21, 211]	[34, 43, 13, 14, 15, 284, 276, 151, 208]	[78, 8, 55, 286, 188, 234, 143, 240]
Increase student motivation/retention	[279, 48, 179, 45, 136, 124]	[33, 101, 34, 183, 16, 249]	[55, 234, 143, 99, 197]
Promote student interactions	[279, 45, 187, 209]	[34]	[8, 188, 233, 17]
Increase student performance		[14, 13, 16]	[286, 180]
Improve student goal achievement	[12]	[14, 13]	
Personalize the learning process	[97]	[151]	
Improve student assignments' quality	[187]		[188]
Show course progress	[112, 48]		
Improve sense of community		[15]	
Improve student self-regulation	[271]		
On-boarding students	[179]		
Distribute usage times	[279]		

Table 2.3: Gamification design purposes in MOOCs.

Game design elements and structures	Empirical studies (MOOC)	Empirical studies (MOOC-like)
Badges	[78, 8, 55, 286, 188, 234, 233, 99, 17, 240]	[220, 166, 37, 160, 270, 154, 167, 250, 243, 156]
Leaderboards / Rankings	[286, 188, 234, 233, 240]	[160, 154]
Badge suites	[8, 55, 240]	[37, 154, 243, 156]
Experience points	[286, 233, 99]	[160, 154, 250]
Votes / Rating	[8, 188, 234]	[166]
Reputation / Karma points	[99, 197]	
Battery / Status bar	[143]	[154]
Progress bar		[270, 250]
Life systems	[286]	
Duels	[286]	[37, 154]
Challenges / Achievements	[240]	[166, 160, 250]
Medals	[99]	
Course privileges	[188, 234]	
Avatars		[154]
Timers		[154]
Mini-games		[272]

Table 2.4: Game design elements and structures implemented in MOOCs.

Conditions	Empirical studies (MOOC)	Empirical studies (MOOC-like)
Interacting with forums (*e.g.*, write, vote)	[8, 188, 234, 233, 143]	[37]
Completing course tasks (*e.g.*,attempts, time)	[78, 55, 143, 240]	[166, 250, 243, 156]
Completing course modules	[55, 188, 234]	[37, 154]
Answering correctly to questions/quizzes /problems	[286, 240]	[272, 220, 166, 160, 154, 243, 156]
Ranking or progressing in leaderboard	[188, 234]	[154, 156]
Interacting with course content (*e.g.*, read, watch)	[8, 143]	[156]
Earning previous rewards	[78]	[160, 154, 167]
Logging in the platform	[143]	
Submitting quality assessments	[78]	
Working efficiently in a group	[55]	
Setting up user profile (*e.g.*, profile picture, preferences)	[233]	
Acquiring competences		[167]
Joining a group		[250]
Participating in social networks		[250]

Table 2.5: Conditions associated to reward-based strategies in MOOCs.

Learning platforms	Empirical studies (MOOC)	Empirical studies (MOOC-like)
iMOOX	[233, 143]	
Telescopio (LRN-based)	[187, 234]	
MéxicoX	[180, 240]	
Coursera	[8]	
SAPO Campus	[17]	
ECO Platform	[99]	
Blackboard CourseSites	[78]	
OpenLearn	[55]	
Coorpacademy	[286]	
Moodle		[220, 37, 270, 250, 156]
Khan Academy		[243]
HTML Academy		[166]
Javala		[160]
Wikispaces		[167]

Table 2.6: Learning platforms used to evaluate the effect of gamification in MOOCs.

frameworks, from which only one is explicitly intended for MOOC contexts [143]. The low number of studies using gamification design frameworks suggests a very poor connection between the efforts done towards the design of successful gamification experiences and the actual gamifications implemented in ongoing MOOCs.

2.5.5 RQ3. Instantiation of Gamification in MOOCs

According to the results, there is not a predominant MOOC platform in which gamification studies are carried out. The iMOOX[27], Telescopio [189] and MéxicoX[28] are the MOOC platforms in which gamification strategies were empirically tested twice (see Table 2.6). Completely different platforms were used in the empirical MOOC-like studies, in which Moodle[29] was the most used platform (5 studies), usually incorporating gamification strategies through external plug-ins. Nevertheless, gamification capabilities in top MOOC providers (*e.g.*, edX, Udacity, FutureLearn, Canvas Network) [257, 259] are still lacking, potentially hindering the general adoption of gamification in these courses.

Additionally, 10 publications describing 7 different technological supporting the orchestration of gamification strategies were found, out of which, 3 were empirically tested in real scenarios: BadgeIt [280], OpenHPI [268, 267] and MyMOOCSpace [227, 228, 226]. Although these systems allow the integration of gamification strategies in MOOCs, several important drawbacks were identified. First, none of these gamification systems tackles the usability and affordability of orchestrating gamification strategies from practitioners' perspective, again hindering their use and adoption. Additionally, most gamification systems and gamification platforms present important constraints regarding the digital representation of gamification designs (*e.g.*, multiple types of rewards, configuration of conditions).

With respect to the informative question: *How gamification is being implemented in MOOCs?*, results (see Table 2.4) revealed that gamification in MOOCs is frequently implemented through reward-based strategies (*e.g.*, badges and badge suites [8], experience points [233]) and social elements (*e.g.*, leaderboards [188], karma points [197], votes [8]). Other less frequent strategies include course privileges [234], medals [99], battery and status bars [143], challenges [240], duels and life systems [286]. Results also showed that similar game design elements and reward-based strategies (*e.g.*, associated conditions) are being implemented in both MOOC and in MOOC-like settings (*e.g.*, SPOCs, remedial courses). Considering that badge suites represent a type of badge organization, and experience and karma points can be conceived as two different types of *points*, the top three elements (*i.e.*, badges, leaderboards and points) identified in this review coincide with the top elements identified in previous literature reviews about gamification in non-recreational [111], educational [67] and MOOC [144] environments. Further work would be needed to understand the reasons for such frequent implementation of these three elements and for the lack of implementation of other types of rewards such as levels in MOOCs.

[27] iMOOX: *https://imoox.at/mooc/*, last access: September 2020.
[28] MéxicoX: *https://www.mexicox.gob.mx/*, last access: September 2020.
[29] Moodle: *https://moodle.org/*, last access: September 2020.

Attending to the empirical studies performed in real MOOC environments, gamification strategies are usually associated to: (1) *interact with discussion forums*, such as writing and reading posts [143], give and receive likes [233] or combinations of the previous ones [234]; (2) *complete course tasks* [78], including quizzes with limited attempts and time [240]; and (3) *complete course modules*, *i.e.*, submit a set of activities from the same module before a specific date [187]. Other completion logic involves *answering correctly* to individual questions [240] or through *duels* with other course participants [286], *progressing in the leaderboard* [187] and *interacting with the course contents* such as reading materials [8] or watching videos [143]. Therefore, most conditions associated to gamification strategies represent quantitative actions that can be monitored by gamification systems, and few conditions require the evaluation of course peers (*e.g.*, *submitting quality assignments*, *working efficiently in a group*). Additionally, it seems remarkable that several studies implementing fine-grained design decisions (*e.g.*, first response to an open question with a positive vote) where implemented with third-party tools external to the MOOC platform [55, 187] or were explicitly developed for the study [180, 240].

2.5.6 RQ4. Reported Effects of Gamification in MOOCs

Results show that the number of empirical studies analyzing the effects of gamification strategies in real MOOC environments is too low (13) to obtain conclusions about the potential benefits of gamification on MOOC participants. While many studies reported positive effects of gamification strategies including higher task submission [272], video watching [286, 154], learning performance [154, 180], forum participation [8] and motivation [187, 234], some studies also reported certain inefficacy from gamification strategies. For instance, although [78, 234] reported an overall student satisfaction with course rewards, both studies conclude that gamification did not increase student engagement and retention.

Furthermore, the evaluation methods utilized to measure the impact on students seem to be weak to obtain solid conclusions about its benefits and how could be reused in other gamified learning situations. For example, four of these studies based their results on student perceptions gathered through a post-course questionnaire which usually is only answered by participants finishing the course [78, 55, 99, 17]. Also, many empirical studies in MOOCs evaluated the effect of gamification by comparing quantitative indicators obtained in a gamified MOOC with previous non-gamified versions of the same course without (1) testing the statistical significance of such differences, and (2) without analyzing whether such differences were produced by the effect of gamification strategies or by any other factor (*e.g.*, number of active participants, practitioners' participation, changes in activities and learning content) [188, 234, 233, 143]. Therefore, although the differences observed in the quantitative indicators of previous studies suggest a positive MOOC learner behavior caused by the addition of gamification strategies, the observed benefits cannot be directly attributed to these strategies.

2.5.7 Discussion

Attending to *RQ1: What is the current state of research on gamification in MOOCs?*, results showed that there is an increasing number of studies addressing gamification in MOOCs. Gamification in MOOCs is starting to be considered as an important research area as shown by the increasing number of journal publications and quality of research. However, there is a scarcity of empirical studies performed in real MOOC environments isolating the effects of concrete gamification strategies and following solid evaluation methods. Therefore, the gamification expected benefits (*e.g.*, increase student engagement and motivation) that were observed in other educational contexts cannot be taken as granted yet.

With respect to *RQ2: Which are the design purposes of using gamification in MOOCs?*, the purposes of using gamification in MOOCs are usually associated to increase student engagement, motivation/retention, interaction and performance. Although there is a high number of conceptual design models and guidelines (14) guiding practitioners in the successful design of gamification strategies for such identified purposes, there is a lack of empirical applications of such proposals. Future studies should address the differences between such frameworks and compare their impact regarding the attainment of the expected gamification effects in real MOOCs.

Regarding *RQ3: How gamification is being instantiated in MOOCs?*, reward (*e.g.*, badges, points, progress bars) and social (*e.g.*, leaderboards, votes/rating) gamification strategies are the most implemented gamification types in MOOC environments. Such MOOC environments usually involve national MOOC platforms such as iMOOX (Austria) and OpenHPI (Germany). However, none of the empirical studies reported in the literature was performed in some top MOOC providers such as edX, Udacity, Canvas Network or MiriadaX [257, 259].

Results also revealed a lack of gamification systems supporting practitioners in the affordable orchestration of gamification strategies in MOOCs. This result is also in line with the outcomes obtained from the MOOC literature review performed by Veletsianos et al. (2016) [273], stating that there is a limited research on practitioner-related topics in MOOCs. Only 15 out of the 183 publications (8.20%) reported practitioners' experiences regarding the design and development of MOOCs, being 'student-focused', 'design-focused' and 'context and impact' the topics of most interest. Further work is needed to analyze the design, implementation and management gamification capabilities of such platforms and to understand their implications in the design of successful gamified MOOCs.

Finally, in regards with *RQ4: What are the reported effects of using gamification in MOOCs?*, overall, general perceptions toward gamification strategies are positive, showing benefits related to higher task submission, video watching, learning performance and forum participation. However, usually the evaluation methods only involved post-course questionnaires without including the perception of dropout students or studied the effects of all gamification elements as a whole without isolating the effects of single strategies or rewards. Therefore, design guidelines for successful gamification in MOOCs based on real experiences are difficult to be extrapolated.

In summary, this literature review helped to understand the current state of gamification in MOOCs and shaped the context of this dissertation. The literature review showed

an increasing interest on using gamification in MOOCs (usually, through reward-based strategies), but at the same time, a scarcity of solid empirical studies confirming its benefits in these environments. Additionally, the literature review served to identify a set of limitations in current MOOC platforms and gamification systems to support the life-cycle of gamified learning situations, thus hindering their use and adoption in real situations.

It is worth considering that this literature review presents some limitations. First, considering the controversy about the use of the "gamification" term to denote reward-based gamifications (see Section 2.3.2), the search string used (*gamif** and **MOOC**) could be excluding relevant publications not considered in the literature review. However, the inclusion of 'snowball references' (*i.e.*, related publications found in the references of the selected papers) reduces the possibility that relevant works that use different terms to refer to this type of gamification such as 'game mechanics' or 'digital badges' have been missed (*e.g.*, [8, 78, 280]).

Second, as observed in this literature review, this research area is in a premature stage, presenting a growing number of publications during the last years. Within the context of this dissertation, the literature review performed in 2017 [210] was then extended in 2019 to include the high amount of papers published during the last two years: 33 new publications (see Fig. 1.2). This rapid evolution of the area poses limitations regarding the validity of this literature review in the medium and long term. In this sense, two literature reviews about gamification in MOOCs have been published in 2020, including 22 [132] and 26 publications [238]. The results of such studies confirm the ones reported in this chapter: scarcity of empirical studies, the most frequent gamification design purposes (*i.e.*, enhance student motivations and engagement), and the game elements used (*i.e.*, badges, leaderboards).

2.6 Conclusions

MOOCs represent a new form of global education that balance traditional and structured classroom-based environments with open and disperse information available on Internet [264]. Despite the positive impact and adoption of MOOCs during the last years, some drawbacks (*e.g.*, lack of interaction, poor instructional design, non-engaging contents) have been pointed out as main reasons for the high dropout rates and student disengagement [140, 141]. Based on the positive results observed in other educational environments (*e.g.*, higher student engagement, higher interaction), gamification is proposed help overcome such drawbacks [59, 144].

Gamification is defined as the use of game design elements (*i.e.*, resources and techniques used in games to motivate and challenge players) in non-game contexts (*e.g.*, online learning). According to previous literature reviews [111, 67], rewards are the game design elements most used in educational contexts, generating the so-called *reward-based gamifications*. Reward-based gamifications can be defined as those strategies issuing game elements (*e.g.*, ribbons, trophies) integrating a signifier (*e.g.*, name, visual) when a completion logic is satisfied (*i.e.*, conditions defined beforehand) [109]. These strategies have been effective in the attainment of potentially useful learners' benefits such as increasing student learning outcomes, increasing student engagement and socialization. On the

contrary, such effectiveness depends on the successful fulfillment of design, instantiation, management and evaluation gamification tasks that practitioners (*e.g.*, learning designers, teachers) must perform. Additionally, MOOCs present some features different than other learning environments (*e.g.*, massiveness, participants' heterogeneity, instructional design) which can hinder the attainment of the expected gamification benefits, adding constraints to the orchestration of gamified activities in MOOCs.

In order to understand the current state of the use of gamification strategies in MOOC environments, we performed a systematic literature review. Results from this literature review showed, on the one hand, the increasing use of reward-based strategies in MOOCs and their general acceptance by MOOC participants. On the other hand, results also revealed a lack of empirical studies performed in real MOOC environments, isolating the effects of rewards, and confirming such benefits observed in other educational environments. Furthermore, the literature review has also evidenced the limited capabilities of current MOOC platforms and gamification systems supporting the affordable orchestration of these strategies in MOOCs.

These two identified limitations are likely to limit the general use and adoption of gamification (from a general view) and of reward-based strategies in MOOCs. With the main purpose of helping overcome such limitations, this dissertation proposes: (1) a set of empirical studies performed in real MOOC environments isolating the effects and perceptions of reward-based strategies on students (see Chapter 3); and, (2) a system integrating a concrete data model and architecture to support the affordable design, instantiation and management of reward-based strategies for MOOC environments (see Chapter 4).

Chapter 3

Analyzing the Effect of Reward-Based Strategies in MOOCs

Summary: Reward-based strategies have been proposed to **increase student engagement** in MOOCs, drawing on evidence that shows positive results in more traditional educational contexts. However, **MOOC specific features** (*e.g.*, massiveness, participants' heterogeneity) can potentially hinder the gamification benefits shown in other educational and non-educational contexts (*e.g.*, traditional classrooms, commercial apps). The literature review described in the previous chapter revealed **the need to perform empirical studies** to inform on the effects of these strategies in real MOOC environments. To face this challenge, this chapter describes **three empirical studies in real MOOC settings** incorporating multiple reward-based strategies. The first two studies report on the effects of badges regarding the level of correlation among behavioral engagement, reward-derived engagement and students' perceptions toward badges. The third study aimed at comparing the effects on student retention, engagement and participation between no gamification, gamification with badges and gamification with course privileges. Finally, the chapter describes the main conclusions emerging from these studies and their relevance.

3.1 Introduction

As introduced in the previous chapter, gamification strategies have been proposed in MOOCs to overcome some of their major problems, including high student disengagement and low participation in course activities [59, 144]. However, the specific features of MOOCs (*e.g.*, massive and heterogeneous set of participants) could hinder the benefits shown in other educational environments. In order to deepen on this issue, the literature review described in Chapter 2 revealed a lack of empirical studies performed in real MOOC environments. Additionally, the few empirical studies found present certain constraints hindering the understanding of how reward-based strategies actually affect student engagement in MOOCs. Some of these empirical studies limited their gamification design to the provision of badges in discussion forums [8, 233, 234], disregarding other MOOC frequent activities such as digital content interaction (*e.g.*, videos, documents), auto-graded quizzes or peer-feedback assignments [35]. Also, those studies extending

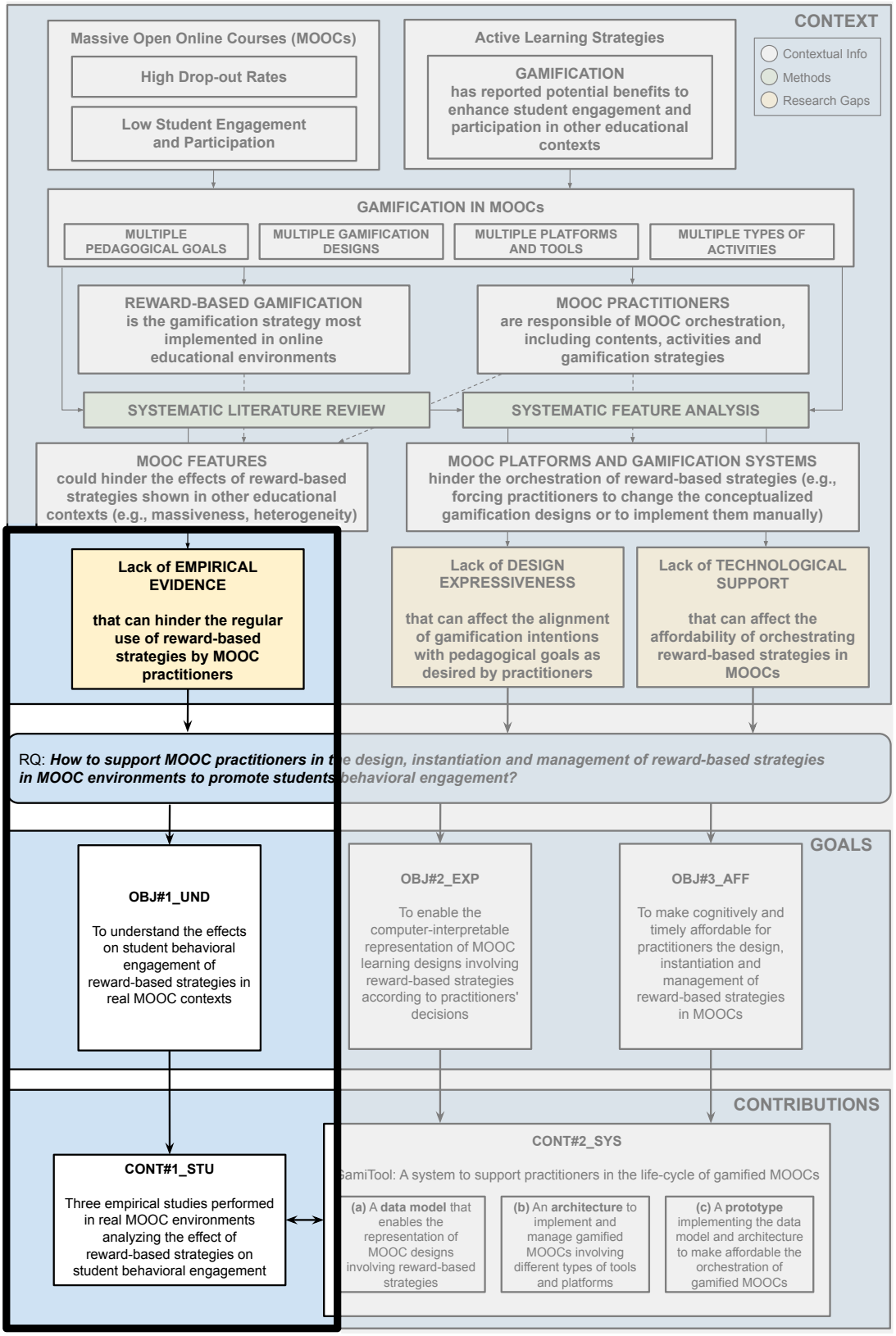


Figure 3.1: Overview of the research problem, objective and contribution addressed in Chapter 3.

their gamification designs to multiple course activities, mainly analyzed the students' self-perceptions reported in questionnaires at the end of the courses [54, 78, 17, 99], without considering their actual behavior during the course, and ignoring the behavior and perceptions of those participants abandoning in the intermediate weeks.

In summary, none of the previous studies addressed the relationship between student engagement, students' perceptions and students' actual behavior caused by reward-based strategies in real MOOC scenarios. Therefore, the lack of understanding on how reward-based strategies affect students' engagement in MOOC contexts potentially hinders their use and adoption by practitioners. Consequently, this limitation led us to confirm the first objective of this dissertation (see *OBJ#1_UND* in Fig. 3.1).

In order to address this objective, we proposed the following research sub-question to be addressed during the first methodological cycle of this dissertation (see *Cycle 0* in Fig. 1.2): *Which are the students' behaviors and perceptions toward earning rewards in MOOCs incorporating reward-based strategies?* By answering this question, we aim to better understand the student reactions and perceptions toward earning rewards, and their relation with other variables measuring engagement. To this end, we performed two empirical studies in real MOOC environments that incorporated a set of reward-based strategies to increase students' engagement (see Sec. 3.3).

In order to deepen in this issue, and as part of the iterative process of this dissertation's methodology (*i.e.*, SDRM), we formulated a second research sub-question during *Cycle 2*: *To what extent reward-based strategies foster student retention, engagement and reward-derived engagement in MOOCs?* Differently from the previous one, by answering this question, we aim to better understand whether differences on student behavior, engagement and retention are actually caused by the attainment of rewards. Section 3.4 describes the third empirical study performed in a real MOOC to help answer this question. In brief, the three empirical studies performed to help answer both research sub-questions represent the first contribution of this dissertation (see *CONT#1_STU* in Fig. 3.1).

The remaining structure of this chapter is as follows. The next section describes the different types of engagement identified in the literature and the focus of this dissertation (Section 3.2). Section 3.3 and Section 3.4 report the contextual information, methodology and results of such empirical studies helping to answer both research questions respectively. Finally, a set of conclusions and potential implications for the design of successful gamified MOOCs are outlined from this work (Section 3.5).

3.2 Student Engagement

This dissertation proposes the use of gamification strategies in MOOC environments to increase student engagement, but actually, what are we referring to *student engagement*? Multiple views and definitions have been provided in the literature to define engagement in learning environments [95, 121]. Actually, three different constructs or types of engagement are frequently reflected in previous studies: behavioral, cognitive and emotional engagement [95, 121].

According to Fredricks et al. (2004) [95], *behavioral engagement* concerns the observable behaviors representing student involvement in learning and academic success

such as attendance, participation, commitment or persistence. Previous studies dealing with student engagement in learning environments usually operationalize 'engagement' as *behavioral engagement* [121]. In technology-mediated environments (such as those involving MOOCs), *behavioral engagement* is frequently measured through digital indicators such as the number of resources accessed, assignments completed, frequency of logins and posts, or the time spent online [121]. *Cognitive engagement* involves students' psychological investment in learning, including self-regulation and meta-cognitive behaviors [95, 121]. As compared with *behavioral engagement*, *cognitive engagement* may not always be externally visible, thus requiring students' self-reporting [121]. In this context, qualitative indicators attempt to understand students' psychological investment through student-created artifacts [121]. Finally, *emotional engagement* refers to students' emotional reactions during the learning experience such as interest, boredom, happiness or anxiety [95]. This engagement construct can be observed by both self-reported information and visible expressions of positive or negative emotion toward learning, course peers and instructors [121].

Although the three engagement constructs could lead to improve MOOC attrition rates, this dissertation focuses on behavioral engagement. As previously mentioned, behavioral engagement is the most frequent engagement construct studied in learning environments. Besides, differently from the other engagement constructs, behavioral engagement represents student observable behaviors which can be automatically tracked by learning and monitoring systems. Therefore, students do not need to be bothered by periodically asking their psychological investment during the learning experience, and thus, reducing the impact of the research design in MOOC contexts. Furthermore, understanding students' emotional engagement would require the interpretation of their emotional reactions based on their comments on discussion forums and private messages. Consequently, addressing this engagement construct would limit our study to only those students posting and sending messages.

Given this context, behavioral engagement in MOOC environments are frequently measured through variables including: the number of resources visited (*e.g.*, videos, pages), the number of on-time submitted tasks, the number of forum posts (entries and replies), and the invested time in the course [150, 87, 164].

Additionally, we realized that the use of reward-based strategies in educational and non-educational environments generates more variables defining student involvement toward earning rewards [118]. Some of these additional variables are participation in gamified tasks, completion of reward requirements or time needed to complete gamified tasks. Another variable representing reward-derived engagement is the time elapsed from the moment that a student satisfies the reward conditions to the moment that the reward is claimed and issued. This variable can potentially inform about the student interest on earning such reward in online learning scenarios [29]. The evidence that students claim the rewards right after satisfying the conditions suggests that they are aware of the existence of rewards and want to earn them. On the other hand, learners claiming all possible rewards just before the end of the course denotes certain interest on reward strategies but with a low engagement level.

This additional set of measures of student engagement corresponds to what we have named, for the purposes of this dissertation, as *reward-derived engagement*. Learners en-

gaged with rewards would be expected to show a higher reward-derived engagement such as the early completion of reward conditions and the performance of a higher number of conditions associated to rewards. Consequently, students showing a high reward-derived engagement (*e.g.*, number of gamified tasks completed) are expected to show high behavioral engagement (*e.g.*, interaction with learning contents). The empirical studies presented in this chapter analyze both the student behavioral and reward-derived engagement in three gamified MOOCs.

3.3 Exploring the Effects of Reward-Based Strategies on Student Engagement

The first two empirical studies explored the effects of reward-based strategies on student engagement, reward-derived engagement and self-perceptions under the *RQ1: Which are the students' behaviors and perceptions towards earning badges in a gamified MOOC?* This section describes the learning and gamification design of such courses, and the research methods and results gathered from the study.

3.3.1 Context

The first course, *By the Seas of Finantial-Economic Translation (EN-ES)*[1], from now on, *TraduMOOCv1*, addressed the topic of English-to-Spanish translation in the business and economic fields. TraduMOOCv1 lasted 8 weeks, from February 6th, 2017, to April 3rd, 2017, being divided into 7 weekly modules (instructor-led MOOC) offered in Spanish. The course was provided by Universidad de Valladolid (Spain), in the Canvas Network platform. The course team was formed by practitioners (one instructor and two teacher assistants) and researchers, who provided teaching and technical support through discussion forums and private messages. The course contained videos and recommended readings (content pages), discussion forums, and individual and collaborative activities (*e.g.*, quizzes, term extraction in groups) [211]. Figure 3.2 depicts the high-level learning design of the course. Course activities were configured to be performed using both Canvas Network native tools (*e.g.*, discussion forums, assignments) and external tools (*e.g.*, Google Forms).

The second MOOC, *Innovative Collaborative Learning with ICT*[2], from now on, *CLaTMOOC*, was provided by Universidad de Valladolid (Spain) and Universitat Pompeu Fabra (Spain), in the Canvas Network platform from June 9th, 2017 to July 28th, 2017 (7 weeks). The topic of this course was related to computer supported collaborative learning in secondary and higher education. ClatMOOC targeted secondary and higher education in-service and pre-service teachers. The course was divided into 6 weekly modules (instructor-led MOOC). The first module, which contained general information about the course contents and tools, was publicly available before the course start.

[1]Original course title: *Por los mares de la traducción económico-financiera (EN-ES)*, available at: *https://learn.canvas.net/courses/1343/*, last access: September, 2020.

[2]Course description available at: *https://www.canvas.net/browse/valladolid-en/courses/innovative-collaborative-learning-en*, last access: September, 2020.

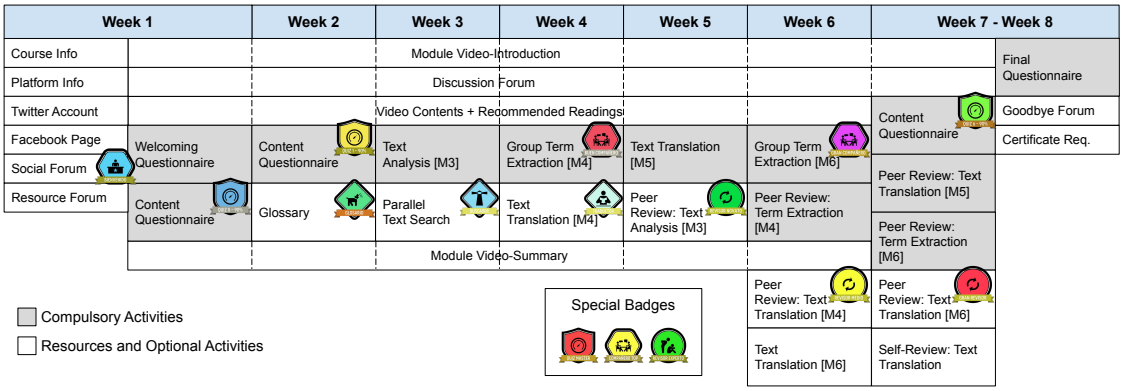


Figure 3.2: TraduMOOCv1 gamification learning design.

Release Week	Image	Name	Condition	Badge Suite
1		*Welcome!*	Introduce yourself in the Social Forum - Cafetería	Social Suite 1
1		*Quiz 0 - 90%*	Get a score, equal or higher than 90% in the questionnaire at Module 1	Quiz Suite 1
2		*Quiz 1 - 90%*	Get a score, equal or higher than 90% in the questionnaire at Module 2	Quiz Suite 2
2		*Glossary*	Participate in the collaborative course glossary of the course	
3		*Searcher*	Search and share examples of descriptive private documents related to economy or marketing	
4		*Good Colleague*	Interact with your group peers and submit the resulting collaborative artifact (Term Extraction - Module 4)	Social Suite 2
4		*Translator*	Translate the optional descriptive public document given in Module 4	
5		*Rookie Reviewer*	Review at least one of the assigned “Text Analysis” peer submissions from Module 3	Review Suite 1
6		*Awesome Colleague*	Interact with your group peers and submit the resulting collaborative artifact (Term Extraction - Module 6)	Social Suite 3
6		*Intermediate Reviewer*	Review at least one of the assigned “Text Translation” peer submissions from Module 5	Review Suite 2
7		*Quiz 6 - 90%*	Get a score, equal or higher than 90% in the questionnaire at Module 7	Quiz Suite 3
7		*Advanced Reviewer*	Review at least one of the assigned “Text Translation” peer submissions from Module 6	Review Suite 3
-		*Quiz Master*	Earn all “Quiz Suite” badges	
-		*Top Colleague*	Earn all “Social Suite” badges	
-		*Expert Reviewer*	Earn all “Review Suite” badges	

Figure 3.3: List of badges and associated conditions configured in TraduMOOCv1.

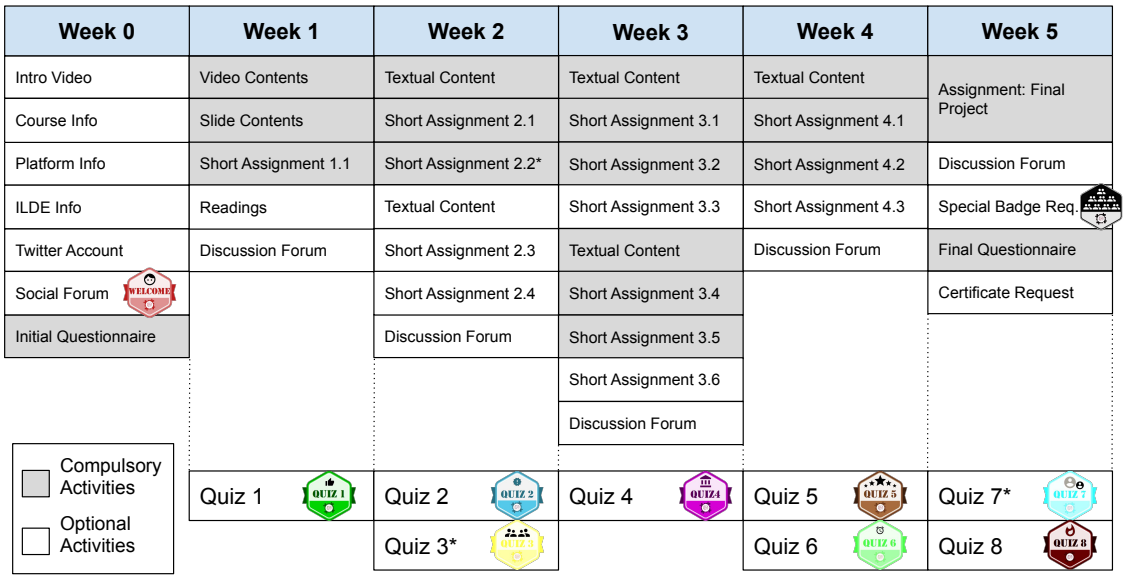


Figure 3.4: ClatMOOC gamification learning design. *Group activities.

				Quiz features			
Release Week	**Image**	**Name**	**Condition**	**Modality**	**Attempts**	**Questions in Advance**	**Timer**
0		*Welcome!*	Introduce yourself in the General Discussion Forum				
1		*Quiz 1!*	Get a 100% score in Quiz 1 (5 questions)	Individual	3	No	No
1		*Quiz 2!*	Get a 100% score in Quiz 2 (5 questions)	Individual	1	Yes	No
2		*Quiz 3!*	Get a 100% score in Quiz 3 (5 questions)	Group	1	Yes	No
3		*Quiz 4!*	Get a 100% score in Quiz 4 (5 questions)	Individual	3	No	No
4		*Quiz 5!*	Get a 100% score in Quiz 5 (5 questions)	Individual	1	No	No
4		*Quiz 6!*	Get a 100% score in Quiz 6 (5 questions)	Individual	1	No	Yes
5		*Quiz 7!*	Get a 100% score in Quiz 7 (5 questions)	Group	1	Yes	No
5		*Quiz 8!*	Get a 100% score in Quiz 8 (5 questions)	Individual	1	No	No
5		*Master Collaborator!*	Get the badges associated to Quiz 3 dnd Quiz 7.				

Figure 3.5: List of badges and associated conditions configured in CLaTMOOC.

Similarly to the previous case, the course included content pages (with self-contained videos and recommended readings), discussion forums, and optional and compulsory activities. The activities were configured to be performed using both Canvas Network native tools (*e.g.*, discussion forums, assignments) and external tools (*e.g.*, ILDE[3] [123]). The course team was formed by four instructors (two per institution) and a set of researchers. The course was offered in two different languages: English and Spanish, having specific discussion forums per module for each language. A summary of the course learning design is depicted in Figure 3.4.

Both courses shared a similar structure, and were provided in the same MOOC platform (Canvas Network). Additionally, in both courses, activities were classified into compulsory and optional attending the requisites to obtain the course completion certificate (students had to submit all the compulsory activities to receive such certificate). However, the topic, target audience, learning design and course goals were different.

3.3.2 Gamification Design and Instantiation

Gamification was co-designed by both the author of this dissertation and the main instructors of the courses. During the co-design phase, the instructor and the researcher agreed on configuring fifteen and ten badges for TraduMOOCv1 and CLaTMOOC respectively, and a badge leaderboard. The reward-based strategies introduced in the learning situation were co-designed with the course instructors with the main purpose of fostering task participation and behavioral engagement in the course. Therefore, the final gamification designs of both courses considered the research purposes of the studies (*e.g.*, gamification of optional activities); the constraints of the gamification platform used (*e.g.*, use of badge achievements); and the pedagogical principles suggested by the course practitioners, who selected those learning activities that were considered most beneficial for students' learning.

Figure 3.3 illustrates the graphical representation and the associated conditions of the fifteen badges implemented in TraduMOOCv1. Badges were associated to different types of tasks aiming to increase student engagement and participation throughout the different weeks of the course. Additionally, badges associated to similar conditions were classified into badge collections (*e.g.*, bronze, silver, gold). Special badges could be claimed once all the badges belonging to a specific collection (*i.e.*, suite) were already earned (see Fig. 3.2). Badge conditions were associated to optional tasks (except for the two collaborative badges) to avoid bias on students' engagement caused by the attainment of the course certificate.

The badges and the leaderboard were implemented using the Badgr platform[4], a badge recognition and tracking system to store, issue, organize, and share Open Badges[5]. The Badgr platform was integrated into Canvas Network using the IMS LTI[6] standard.

CLaTMOOC implemented ten badges associated to optional quizzes distributed in

[3]The Integrated Learning Design Environment: *https://ilde.upf.edu/*, last access: September, 2020.
[4]Badgr: *https://info.badgr.io/*, last access: September, 2020.
[5]Open Badges: *https://openbadges.org/*, last access: September, 2020.
[6]Learning Tools Interoperability: *https://www.imsglobal.org/activity/learning-tools-interoperability*, last access: September, 2020.

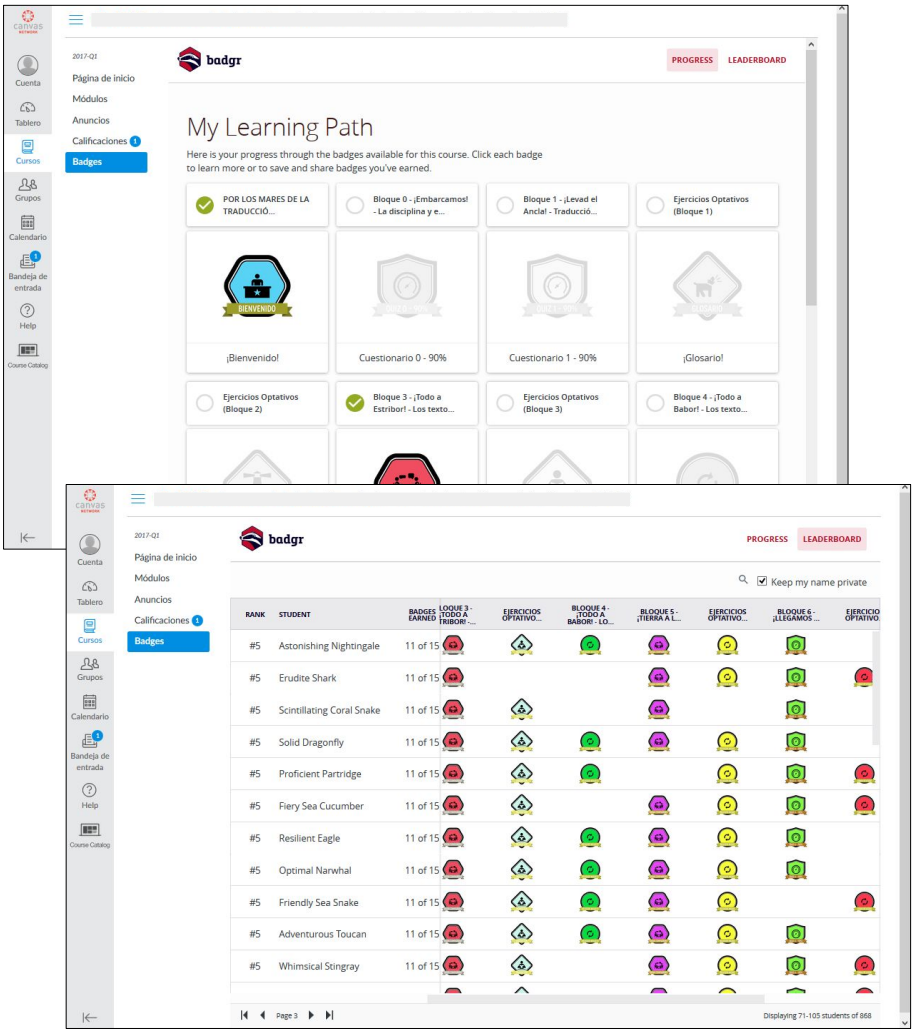


Figure 3.6: Screenshots of the badge tab from the student view [207].

the different modules of the course (except one badge to promote self-presentation in the general forum of the course). The optional quizzes were implemented with the Canvas 'questionnaire' native tool and configured with different features as described in Figure 3.5. Students had to score 100% (5 questions regarding the module contents) in those gamified quizzes to be eligible for the associated badges. Collaborative quizzes were administered in advance to 5-6 person groups[7], which had a dedicated discussion forum to discuss the quiz answers before final submission. While CLaTMOOC gamification design only contained badges associated to 100% score in optional quizzes, TraduMOOCv1 implemented badge conditions related to different types of activities (typically associated to their completion and submission).

In both courses, gamification was visible by means of a tab located in the web user interface of the MOOC platform, where students could check the badges earned, the conditions to earn them, and track their achievements in the leaderboard (see Fig. 3.6). Badges were issued once students satisfied their conditions and explicitly accessed to the added "gamification tab", allowing to better distinguish those students that unintentionally completed badge conditions. When students visit the gamification tab, Badgr is able to check whether badge conditions were satisfied, issue and display them in the student interface. Students were informed about the existence of badges through the course description page, which was always available, through short reminders included in the descriptions of the gamified activities, and through the gamification tab.

It is worth to mention that TraduMOOCv1 course team wanted to implement a more complex gamificaiton design. For instance, badge conditions associated to student actions performed in the external tools used for some course activities such as the collaborative glossary (*i.e.*, Google Forms). However, the gamification platform used (*i.e.*, Badgr), presented some limitations that constrained such complex designs. Consequently, in order to gamify this activity with the Badgr tool, students were requested to copy and paste the glossary terms added in the Google Form, in a submission page inserted in Canvas Network to automatically issue them. This same approach was also implemented in other gamification studies constrained by gamification platforms [77, 55].

3.3.3 Methodology and Data Sources

As previously stated, the general research question guiding both studies was: *Which are the students' behaviors and perceptions towards earning badges in a gamified MOOC?* To help answer the research question, we conducted an anticipatory data reduction process during the evaluation design [185]. As part of this reduction process, we defined an issue [266] as a conceptual organizer of the evaluation process: *Which are the students' behaviors and perceptions towards earning badges in the MOOC of the study?* Additionally, this issue was further divided into two different topics: *(topic 1)* behavioral and reward-derived student engagement; and *(topic 2)* learners' personal perceptions toward rewards and its relationship with their engagement.

Quantitative and qualitative data were collected to better understand the relationship between the learners' behavior within the course and their interest on badges. The data sources employed in both studies were:

[7]Groups were formed according to language preferences and previous activity in the course.

- **Canvas Network Log**. Registry of learner actions performed in the MOOC platform. This registry contains general information about the course (*e.g.*, total number of enrolled students, active students per week) and about participants' actions (*e.g.*, number of pageviews, tasks submitted and forum posts).

- **Badgr Log**. This log includes information about the issued rewards (*e.g.*, number of badges issued, rewarded participants). This data source provided useful information to calculate students' reward-derived engagement.

- **Canvas Pre-Questionnaire**. Information retrieved from the MOOC platform regarding the answers provided by students in the initial questionnaire of the course. This information allowed to profile MOOC learners in both courses (*e.g.*, age, gender, background).

- **Canvas Post-Questionnaire**. Information retrieved from the MOOC platform regarding the answers provided in the last-module questionnaire about participants' experience and perceptions toward course gamification. The questionnaire contained 12 and 8 likert-like items (TraduMOOCv1 and CLaTMOOC, respectively) and 1 open-ended question to further understand the reasons for the quantitative answers.

Full information about pre- and post- questionnaires can be found in Appendix A. Questionnaires' content-related evidence of validity (*i.e.*, definition, sample, content and format) [94] was obtained by three TEL research experts from GSIC-EMIC group (and one course student in TraduMOOCv1). Finally, all data was homogenized (*e.g.*, timestamps) in multiple MS Excel files and processed with RStudio[8] and Google Spreadsheets[9] software.

3.3.4 Participants

TraduMOOCv1 registered 1031 enrollments out of which 668 (64.79%) and 140 (13.58%) completed the initial and final questionnaire, respectively. As presented in Figure 3.7, most participants were women (75.75%), between 20-30 years old (61.23%), living in Spain (56.89%), with university degree (53.29%), medium knowledge level about the MOOC topic (41.32%), without previous MOOC experience (65.87%), and planning to actively complete all course activities (57.78%).

CLaTMOOC registered 632 participants out of which 179 (28.32%) and 39 (6.17%) submitted the initial and final questionnaire, respectively. According to the results provided in the initial questionnaire (see Fig. 3.7), course participants represented an heterogeneous set of participants regarding gender, age, education level, location, and previous experience in MOOCs, typically observed in this type of courses [256].

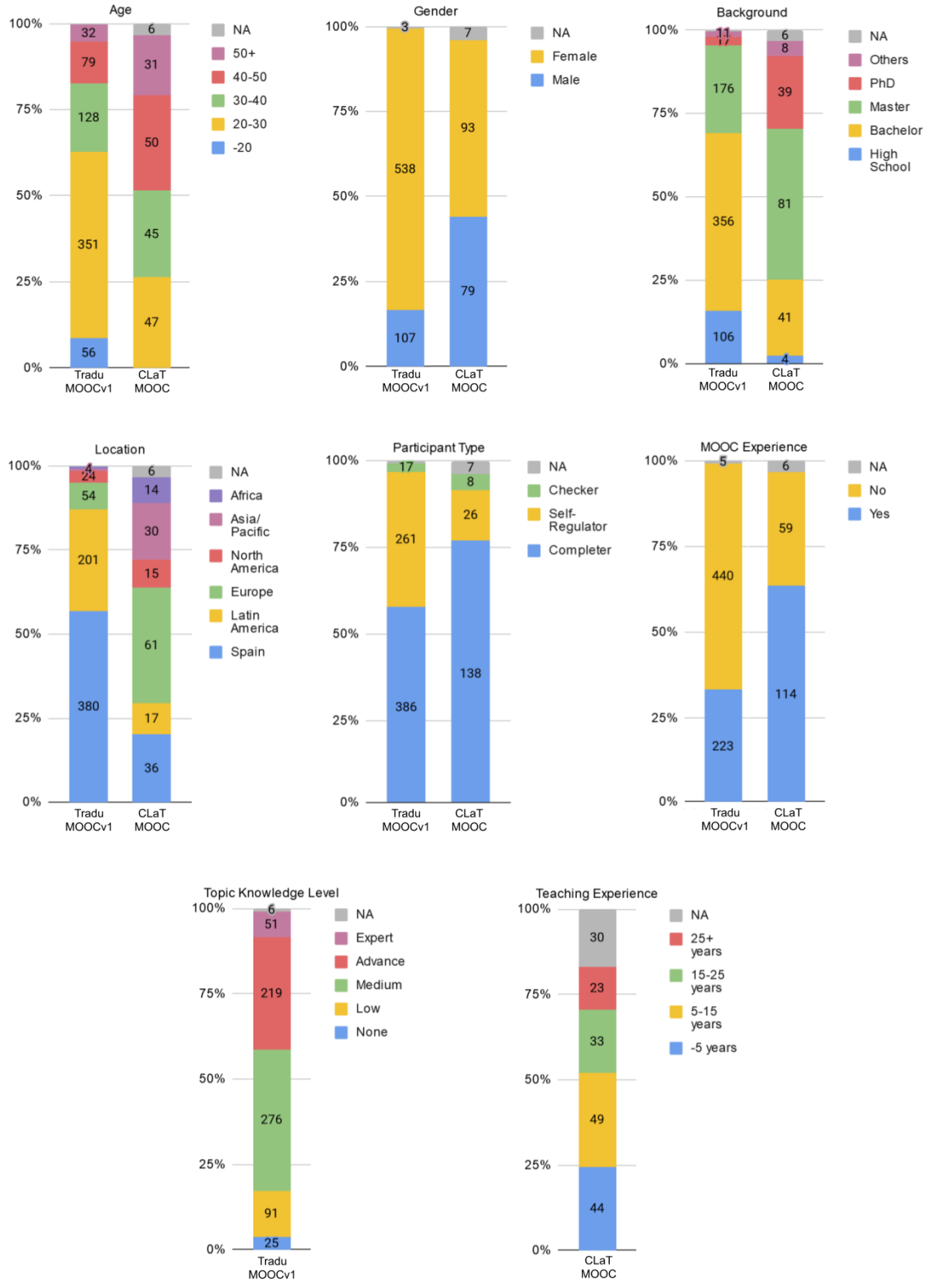


Figure 3.7: MOOCs participants' demographic information: TraduMOOCv1 (N=668) and CLaT-MOOC (N=179).

Badge	*Welcome*	*Quiz 0 (90%+)*	*Quiz 1 (90%+)*	*Glossary*	*Searcher*	*Good Colleag.*	*Translat.*	*Rookie Review.*	*Awesome Colleag.*	*Interm. Review.*	*Quiz 6 (90%+)*	*Adv. Reviewer*	*Top Colleag.*	*Quiz Master*	*Expert Review.*
Active studs. (week)	668	668	294	294	163	146	146	143	144	144	154	154			
Accomplished	302	247	240	122	92	146	108	116	144	96	141	94	102	107	59
Claimed and earned	282	227	191	112	84	126	96	103	117	87	117	80	91	94	53
Ratio info (%)															
Accomplished/Active	45.21	36.98	81.63	41.50	56.44	-	73.97	81.12	-	66.67	91.56	61.04			
Earned/Accomplished	93.38	91.90	79.58	91.80	91.30	86.30	88.89	88.79	81.25	90.62	82.98	85.11	89.22	87.85	89.83
Span info (days)															
Median	1.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00
Mean	3.18	1.90	2.34	3.00	3.05	5.34	4.65	3.75	2.29	3.53	0.95	0.55	2.32	1.09	0.60

Table 3.1: TraduMOOCv1 descriptive statistics regarding reward-derived engagement variables.

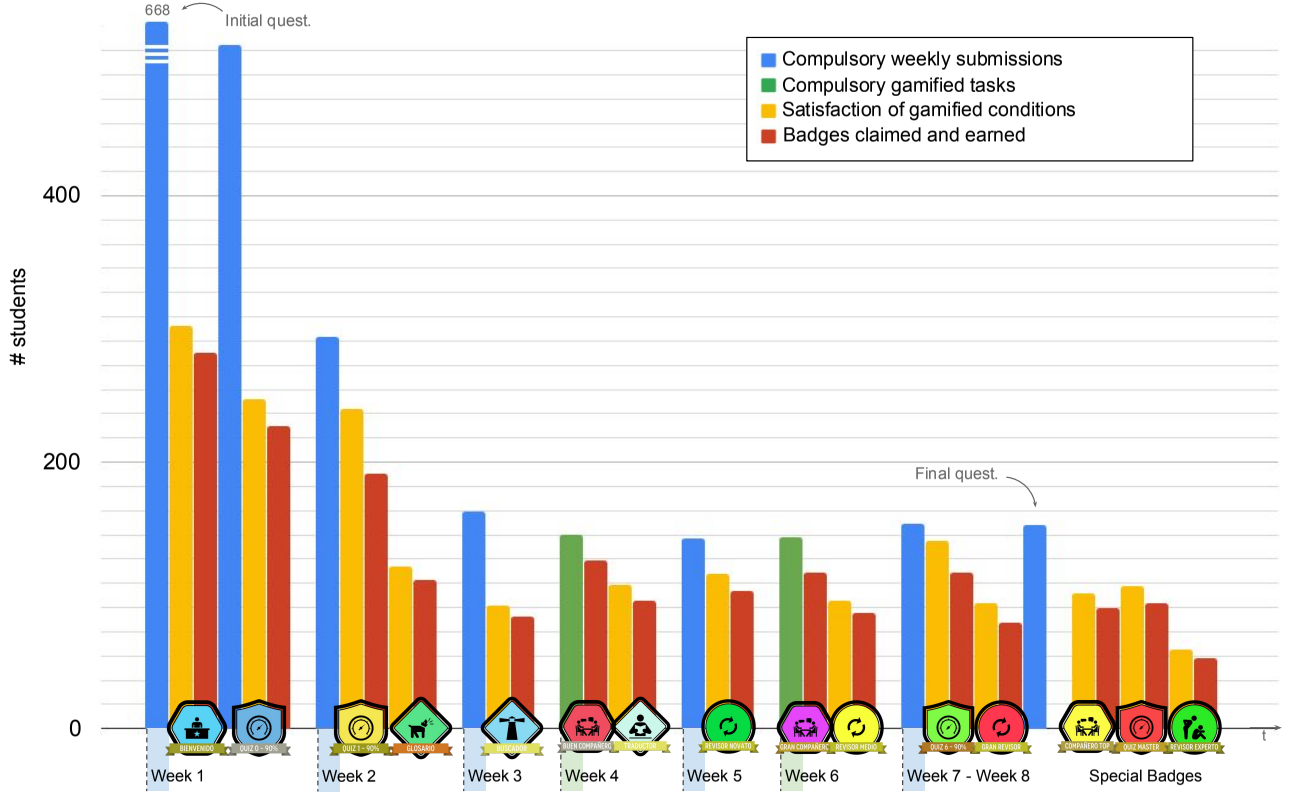


Figure 3.8: Overview of students' reward-derived engagement throughout TraduMOOCv1 course.

Badge	*Welcome*	*Quiz 1*	*Quiz 2*	*Quiz 3*	*Quiz 4*	*Quiz 5*	*Quiz 6*	*Quiz 7*	*Quiz 8*	*Top. Col.*
Active studs. (week)	179	66	60	60	38	35	35	31	31	
Participated	86	96	65	24	37	32	32	17	30	16
Accomplished	86	43	11	6	15	14	14	7	10	4
Claimed and earned	38	22	7	5	15	7	8	6	8	4
Ratio info (%)										
Participated/Active	48.04	145.45	108.33	40.00	97.37	91.43	91.43	54.84	96.77	-
Accomplished/Active	48.04	65.15	18.33	10.00	39.47	40.00	40.00	22.58	32.26	-
Earned/Accomplished	44.19	51.16	63.64	83.33	100.00	50.00	57.14	85.71	80.00	100.00
Span info (days)										
Median	0.50	0.00	1.00	0.00	0.00	2.00	4.50	0.00	0.00	0.50
Mean	6.45	4.50	3.71	3.00	3.73	3.71	5.00	0.33	2.00	0.50

Table 3.2: CLaTMOOC descriptive statistics regarding reward-derived engagement variables.

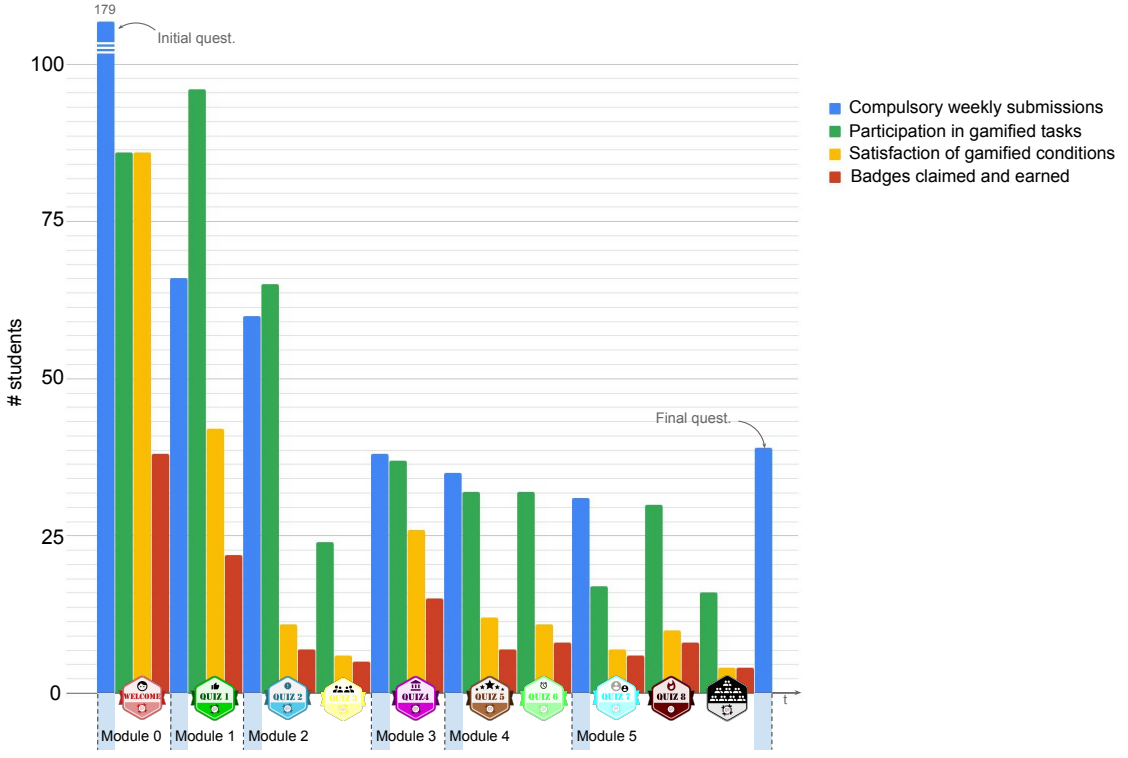


Figure 3.9: Overview of students' reward-derived engagement throughout the CLaTMOOC course.

3.3.5 Topic 1: Behavioral and Reward-Derived Engagement

Reward-derived Engagement: Number of Badges and Satisfaction of Conditions

A total number of 1860 and 120 badges were issued to 368 and 47 distinct students in the TraduMOOCv1 and CLaTMOOC, respectively. This supposes that 55.09% and 33.57% of participants who submitted the initial questionnaire (*i.e.*, had the possibility to know about badges), earned at least one badge. In both courses, the ratio of students satisfying reward conditions and claiming the reward (earned/accomplished) was high and stable throughout the course (on average, 87.92% and 71.52% for TraduMOOCv1 and CLaTMOOC, respectively).

Looking from a temporal perspective, results (see Fig. 3.8 and Fig. 3.9, respectively) show a sharp decrease of active students (students submitting compulsory weekly tasks) during the first two weeks, which then slightly decreased until the end of the course, a trend often observed in MOOC contexts due to the enrollment of different learner profiles [3]. The number of students satisfying the reward conditions and earning badges followed a more moderated decreasing trend (see Table 3.1 and Table 3.2).

Regarding TraduMOOCv1, further analysis was conducted to investigate the influence of badges associated to different types of activities. Accomplished/active ratio in badges associated to quiz performance showed an increasing trend throughout the course: 36.98% (*Quiz 0*, week 1), 81.63% (*Quiz 1*, week 2) and 91.56% (*Quiz 6*, week 7) (see Table 3.1). However, badges associated with peer-review participation presented a decreasing trend despite their release started in the third week (after which dropouts were minimal): 81.12% (*Rookie Reviewer*, week 5), 66.67% (*Intermediate Reviewer*, week 6) and 61.04% (*Advanced Reviewer*, week 7). Additionally, independent badges showed diverse ratios depending on the activity type: 41.50% (*Glossary*, week 1), 56.44% (*Searcher*, week 2) and 73.97% (*Translator*, week 3). Therefore, badges associated to quiz performance seemed to be much more popular than the ones associated to other activity types.

Differently from TraduMOOCv1, reward-derived engagement in CLaTMOOC was also measured in terms of participation in gamified quizzes due to the high difficulty of achieving a 100% score in gamified quizzes (see accomplished/active ratio in Table 3.2). During the first two weeks, the number of students that participated in gamified quizzes was higher than the number of students participating in compulsory activities (module 1: 96 vs. 66, module 2: 65 vs. 60). This fact denotes a high interest on optional gamified quizzes during such initial weeks. From the third week onward, the participation in gamified quizzes was similar to the participation in compulsory course assignments except for collaborative quizzes.

Quizzes conceived to be collaboratively solved (*Quiz 3* and *Quiz 7*) experienced less participation as compared with individual quizzes (40.00% and 54.84%, respectively). This low participation could be initially attributed to the fact that questions were provided in advance to be discussed with course peers and submitted in one single attempt. However, Quiz 2 questions were also provided in advance with one single attempt but the participation level was very high (108.33%). Therefore, these differences in the level of participation suggest that collaborative solving reduces the level of participation in gami-

[8]RStudio: *https://rstudio.com/*, last access: February, 2020.
[9]Google Spreadsheets: *https://www.google.es/intl/es/sheets/about/*, last access: February, 2020.

fied quizzes. Additionally, the low number of students getting 100% score in Quizzes 2, 3 and 7 (yellow bar in Fig. 3.9) indicates that although students showed certain interest on this gamified quiz (high participation, green bar), students did not dedicate time to find the correct answers in the content resources.

On the other hand, *Quiz 4* (one week later), was configured without providing the questions in advance but having 3 attempts to obtain the 100% score. This gamified quiz registered less participation than *Quiz 2* but showed a much higher ratio of students completing the conditions *vs.* students participating (70.27% Quiz 4 *vs.* 16.92% Quiz 2) and a higher number of students achieving the associated badge (15 in Quiz 4 *vs.* 7 in Quiz 2). These results suggest that the number of attempts seems an important parameter to promote quiz participation and should be considered in the design of successful reward-based strategies. Finally, *Quiz 6*, which was configured with a 3-minute timer, presented similar results than other quizzes configured with the same parameters without timers (*e.g.*, *Quiz 5*, *Quiz 8*). Therefore, in this context, the timer or the time configured did not seem to represent a challenging parameter for students.

Reward-derived Engagement: Claiming Time Span

In order to understand to which extent engagement can be attributed to rewards, we analyzed the time span between the moment that students were eligible for a badge (*i.e.*, badge condition satisfaction) and the moment it was claimed. Results (see Table 3.1 and Table 3.2) show that the median varies from 0 (*i.e.*, the same day) to 1 day for almost every badge. Furthermore, the 95% confidence interval (see Fig. 3.10 and Fig. 3.11) was calculated to estimate the claiming time span interval for other potential MOOC populations [195].

Regarding TraduMOOCv1, results show an initial growth from the beginning (3.18$\pm$ 0.43 days; n=282) to the middle of the course (4.65$\pm$1.37 days; n=96), and a decrease from the middle to the end of the course (0.55$\pm$0.30 days; n=80). The initial growth could be attributed to a loss of interest in earning badges, and the decrease towards the end of the course might be explained by the short time students had to claim badges before the course end. These results suggests that students' reward-derived engagement decreased throughout the course. However, interval ranges are under the threshold of 7 days for every badge (release time for a new module and badges), suggesting a positive behavior toward rewards.

Regarding CLaTMOOC, 95% confidence interval ranges were, in general, larger than in TraduMOOCv1. Moreover, although median values varies from 0 to 1 day for almost every badge, the upper value for the first seven badges was over 7 days (release time for new module and badges). These results denote that students from CLaTMOOC were less engaged toward badges than the students from TraduMOOCv1.

Reward-derived Engagement vs. Behavioral Engagement

The relationship between the variables modeling behavioral engagement and the variables modeling reward-derived engagement was analyzed in order to understand whether students more engaged with course contents and activities were also engaged with reward-based strategies. To this end, a bivariate Pearson correlation analysis [182] was performed

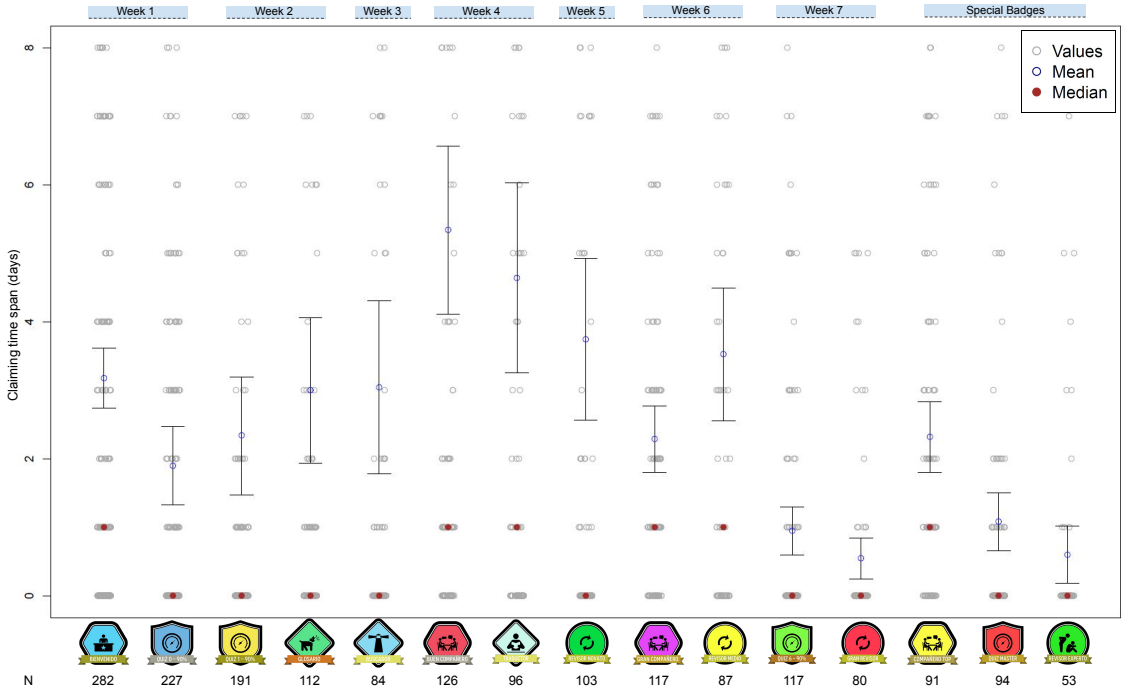


Figure 3.10: TraduMOOCv1: 95% confidence interval regarding the claiming time span per badge.

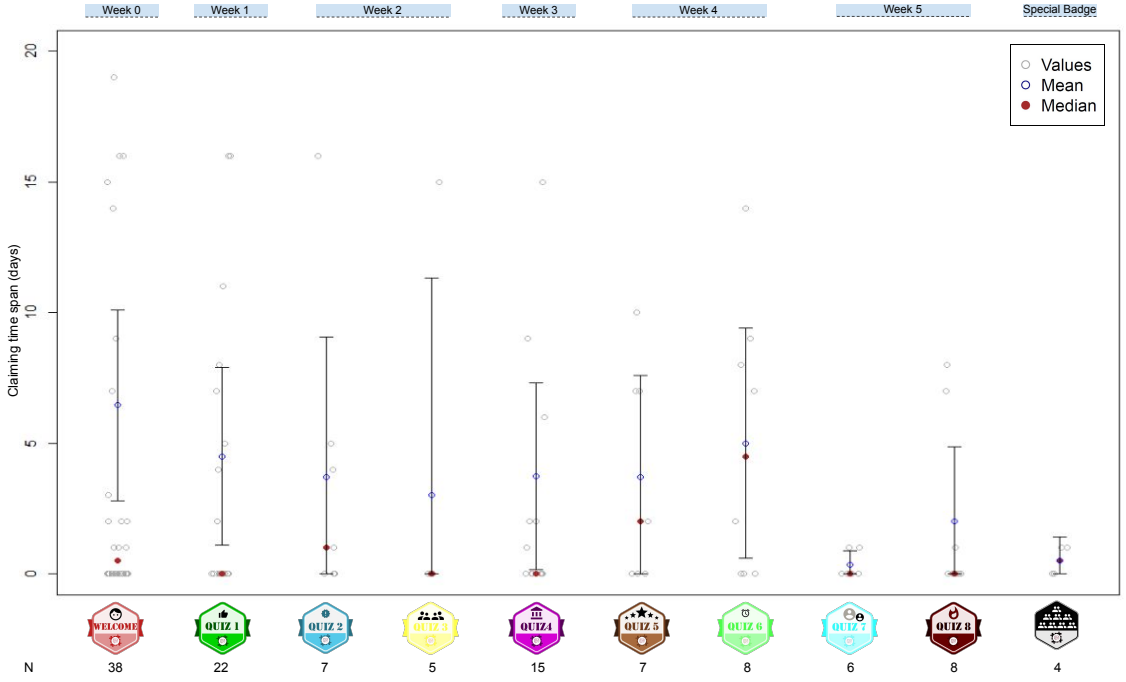


Figure 3.11: CLaTMOOC: 95% confidence interval regarding the claiming time span per badge.

	Pageviews	Assignments	Forum Posts	Activity Time
# badges	0.822*	0.919*	0.563*	0.322*
Average claiming time	-0.062	-0.076	-0.018	0.033

Table 3.3: TraduMOOCv1: Pearson correlation between behavioral and reward-derived engagement variables (students submitting the initial questionnaire, N=668). *Significant at .05 level.

	Pageviews	Assignments	Forum Posts	Activity Time
# badges	0.517*	0.820*	0.360*	0.188*
Average claiming time	-0.174*	-0.345*	-0.034	-0.025

Table 3.4: TraduMOOCv1: Pearson correlation between behavioral and reward-derived engagement variables (students submitting the final questionnaire, N=153). *Significant at .05 level.

	Pageviews	Assignments	Forum Posts	Activity Time
# badges	0.604*	0.495*	0.491*	0.281*
Participation in quizzes	0.815*	0.770*	0.619*	0.140
Average claiming time	0.039	-0.011	-0.057	0.120

Table 3.5: CLaTMOOC: Pearson correlation between behavioral and reward-derived engagement variables (students submitting the initial questionnaire, N=179). *Significant at .05 level.

	Pageviews	Assignments	Forum Posts	Activity Time
# badges	0.492*	0.378*	0.346*	0.432*
Participation in quizzes	0.580*	0.410*	0.363*	0.208
Average claiming time	-0.167	-0.428*	-0.258	0.087

Table 3.6: CLaTMOOC: Pearson correlation between behavioral and reward-derived engagement variables (students submitting the final questionnaire, N=39). *Significant at .05 level.

based on the continuous nature of the measured variables. The analysis has been performed considering two clusters: students submitting the initial questionnaire and students submitting the final questionnaire. Both analyses can help understand differences between those students abandoning the course in the intermediate weeks and those students finishing the course. Results are presented in Table 3.3 and Table 3.4 for TraduMOOCv1 and in Table 3.5 and Table 3.6 for CLaTMOOC.

According to the results, TraduMOOCv1 students submitting the initial questionnaire presented a statistically significant high positive correlation between the number of badges earned and the number pageviews ($\rho = 0.822$), and the number of submitted assignments ($\rho = 0.919$), a significant moderate positive correlation with the number of forum posts ($\rho = 0.563$), and a significant low correlation with the activity time ($\rho = 0.322$). Non-significant correlation was found between the average claiming time span and the variables measuring behavioral engagement.

Similarly, CLaTMOOC students submitting the initial questionnaire presented a significant moderate correlation between the number of badges earned and the number of pageviews ($\rho = 0.604$), and a significant low correlation with the number of submitted assignments ($\rho = 0.495$), the number of forum posts ($\rho = 0.491$) and the activity time ($\rho = 0.281$). Additionally, a significant high positive correlation was found between the number of participations in gamified quizzes and the number of pageviews ($\rho = 0.815$) and the number of submitted assignments ($\rho = 0.770$), and a significant moderate correlation with the number of forum posts ($\rho = 0.619$). Non-significant correlation was found between the average claiming time span and the variables measuring behavioral engagement. Students submitting the final questionnaire presented similar results with lower correlation levels in both courses. Therefore, results indicate that those students that were more engaged with the course, earned more badges and participated more in gamified quizzes. Nevertheless, it is worth mentioning that correlation does not imply causality (*i.e.*, students were more engaged because they earned more badges) and further work is needed to understand this relationship.

Reward-derived Engagement: Analysis per Student

Individual student analysis can help cluster the different behaviors toward badges in the course. Regarding TraduMOOCv1, we created two heat maps (see Figure 3.12) including (a) the students that reached the last course module, and (b) the dropout students (lurkers and students that at a certain point of the course stopped completing course activities [4]).

According to the heat maps, most students (active and dropout students) earned 100% of the badges that they could earn, and claimed them on average in less than 7 days (before the release of the badges of the next module). Looking into the graph of active students, there is an important set of students (N=70) earning a high number of badges (Group A, students who earned 12+ badges) in a short claiming time span (on average, 1.79 days). According to the answers provided in the final questionnaire, 60 out of 70 (85.71%) students in Group A reported that badges motivated them to complete course activities. Some students' open answers supporting this fact are *"The fact of knowing that after finishing a task you could obtain a badge was a good motivation to do all tasks"* or *"Badges were like an impulse, like a goal to reach together with the grades"*.

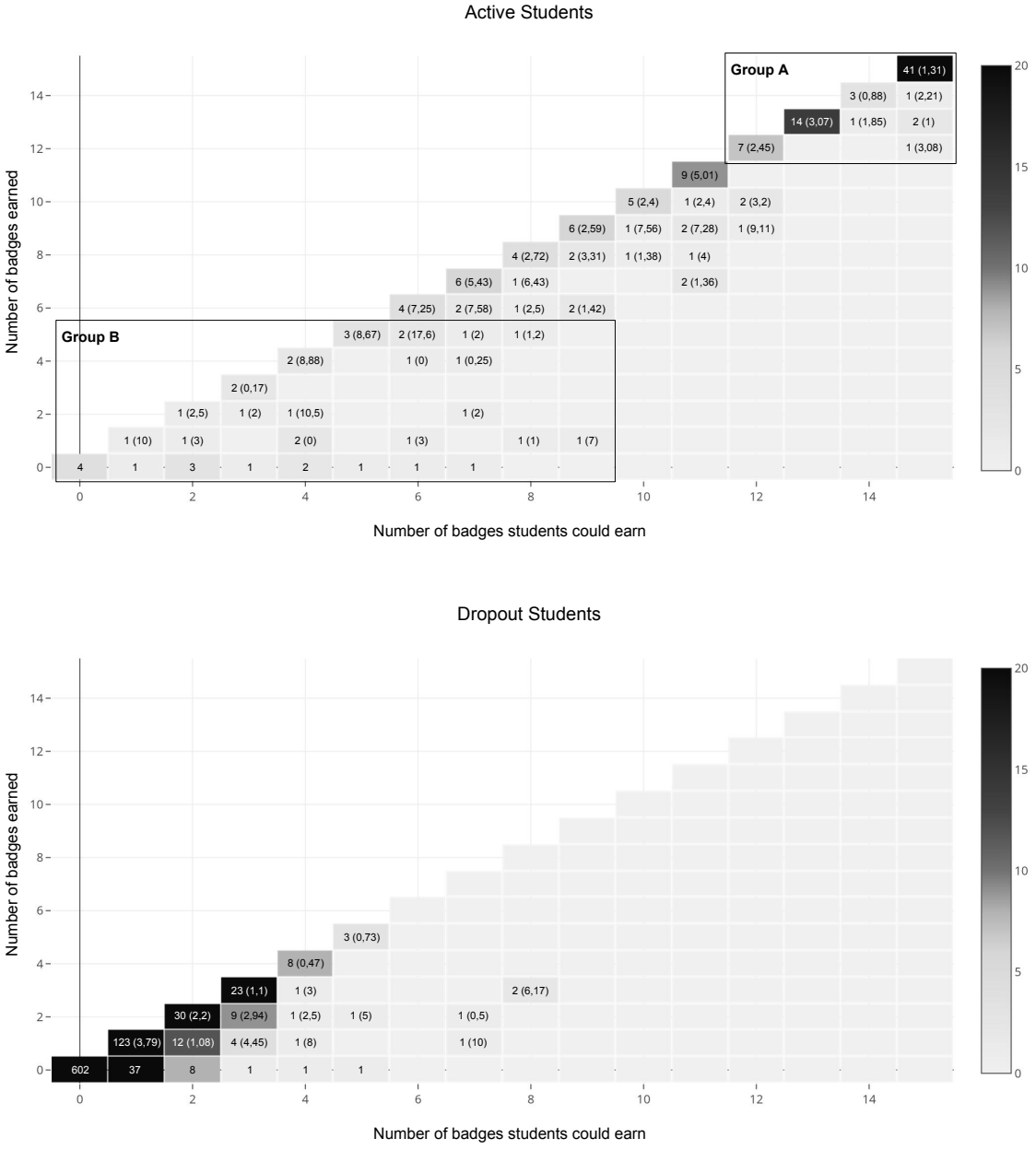


Figure 3.12: TraduMOOCv1: Heatmaps of the number of active (top) and dropout (bottom) students regarding the number of claimable badges *vs.* the actual number of badges earned. The darker color indicates a higher number of students, and the number in parenthesis, the average claiming time span [207].

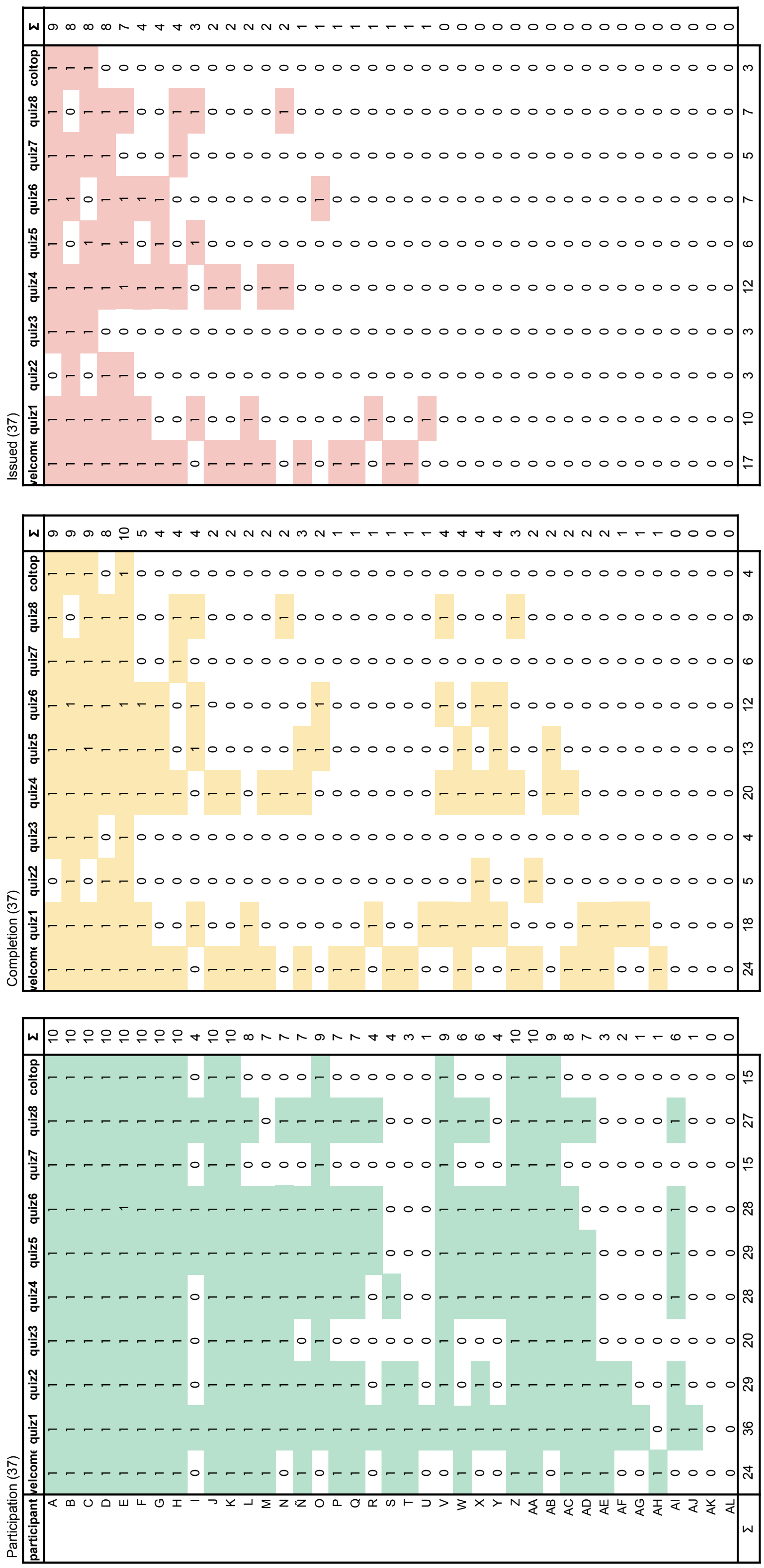


Figure 3.13: CLaTMOOC: Reward-derived engagement of students completing the final questionnaire: (left) participation in gamified activities; (middle) satisfaction of gamified conditions; (right) claimed and issued rewards.

On the other hand, there was a considerable number of students (N=38) who were active until the end of the course but had a low performance towards earning badges (Group B, students who earned 5- badges) with a higher claiming time span (on average, 5.16 days). Student answers in the final questionnaire showed a lack of positive motivation caused by badges (12 out of 38 students, 31.58%) Some of the reasons that students provided in the final questionnaire were: *"To be honest, I didn't care about badges. I only focused on compulsory activities, the ones interesting for my learning"* or *"My motivation to do tasks was related to learning rather than badges. However, it doesn't mean it is a bad idea"*. Furthermore, the fact that most students belonging to Group B (being active until the end of the course) earned badges during the first weeks of the course suggests an initial interest on badges that seems to disappear throughout the course (as previously observed). This behavior was also mentioned by some students in the final questionnaire (*e.g.*, *"At the beginning of the course I wanted to earn badges, but as the course progressed I could devote less and less time to it because of my work"*).

Regarding the CLaTMOOC, we analyzed the reward-derived engagement of those students submitting the final questionnaire (students expected to be active during the whole course). Figure 3.13 depicts the reward-derived engagement (participation in gamified activities, satisfaction of gamified conditions and issued rewards) of these students. According to the results, 26 out of 39 (66.67%) students participated in tasks and quizzes associated to course badges. Additionally, the participation in gamified quizzes was higher than the participation in the general forum which was associated to the *Welcome* badge. This fact supports the previous findings suggesting that rewards associated to quizzes led to higher reward-derived engagement than other activities (*e.g.*, group activities).

Results also denoted that the difficulty of the quizzes was high (low ratio participation *vs.* completion) in quizzes with one single attempt. This information can be useful for the redesign of future versions of the course (editing badge conditions to 80%, thus allowing students to fail one question per quiz). Furthermore, the 3-minute timer quiz (Quiz 6) did not present significant differences on student participation (29 *vs.* 28 students), satisfaction of conditions (13 *vs.* 12 students) and badge claiming (6 *vs.* 7 students) as compared with the other gamified quiz of the same module (Quiz 5). Finally, while the badges were more frequently claimed and earned in the first weeks of the course, only few students were actively claiming and earning them at the end of the course. Such results highlight the drastic decrease of interest on course badges throughout the course as observed in the claiming time span analysis.

3.3.6 Topic 2: Students' Perceptions toward Badges

Students' perceptions toward badges (*i.e.*, students' beliefs about the effects of badges on their motivation and engagement) were studied using various categories of statements in the final questionnaire (see Table 3.7 and Table 3.8 for TraduMOOCv1 and CLaTMOOC respectively[10]): (C1) motivation caused by badges, (T1) benefits of gamified quizzes, (C2,T2) reasons to earn badges, (C3,T3) perceived effects of badges on behavioral en-

[10]A reduced number of items were included in the CLaTMOOC questionnaire due to the inclusion of additional statements for other research purposes, thus keeping the longitude of the questionnaire short and expecting to be completed by a higher number of participants.

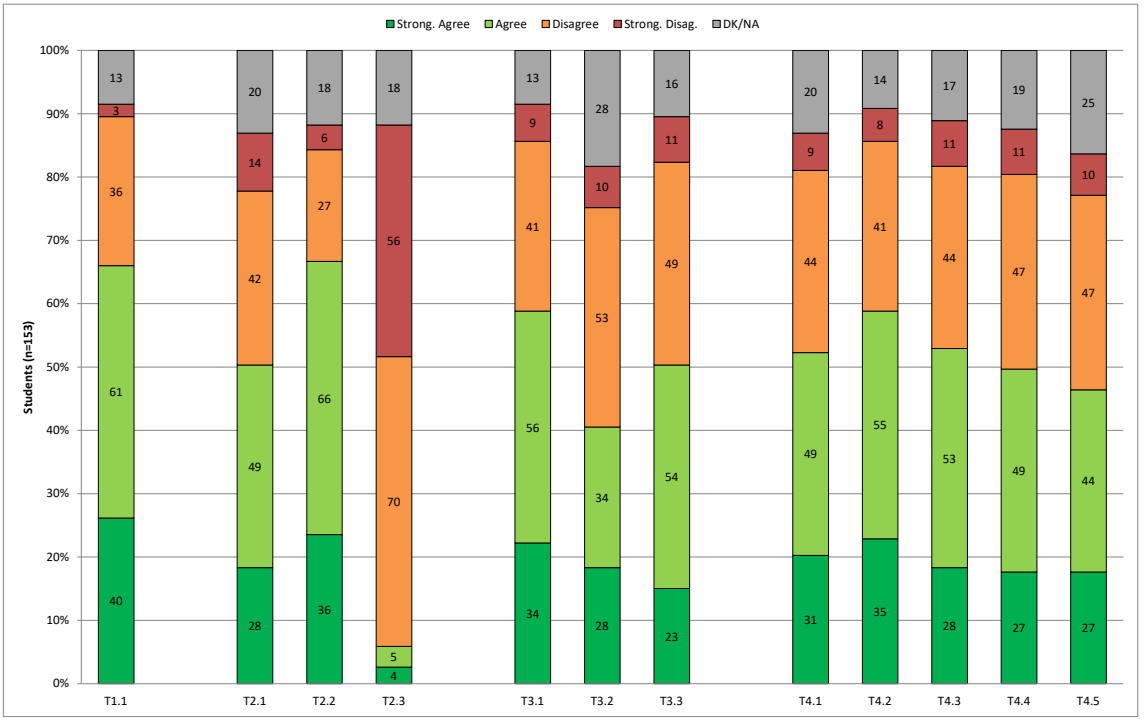


Figure 3.14: 100% stacked bars regarding the students' answers in TraduMOOCv1 final survey related to course badges. The questionnaire statements are described in Table 3.7 [207].

	Statements
T1.1	The possibility of earning badges increased my motivation to complete course activities
T2.1	I tried to earn the badges because I liked to collect them
T2.2	I tried to earn the badges because they showed my progression in the course
T2.3	I tried to earn the badges because I competed with other students
T3.1	Earning the different course badges made me complete more course tasks
T3.2	Earning the different course badges made me visit more course pages
T3.3	Earning the different course badges made me spend more time in the course
T4.1	Earning the different course badges encouraged me to participate in peer reviews
T4.2	Earning the different course badges encouraged me to participate in quizzes
T4.3	Earning the different course badges encouraged me to participate in group activities
T4.4	Earning the different course badges encouraged me to participate in discussion forums
T4.5	Earning the different course badges encouraged me to participate in the glossary

Table 3.7: Description of TraduMOOCv1 final questionnaire items related to course badges [207].

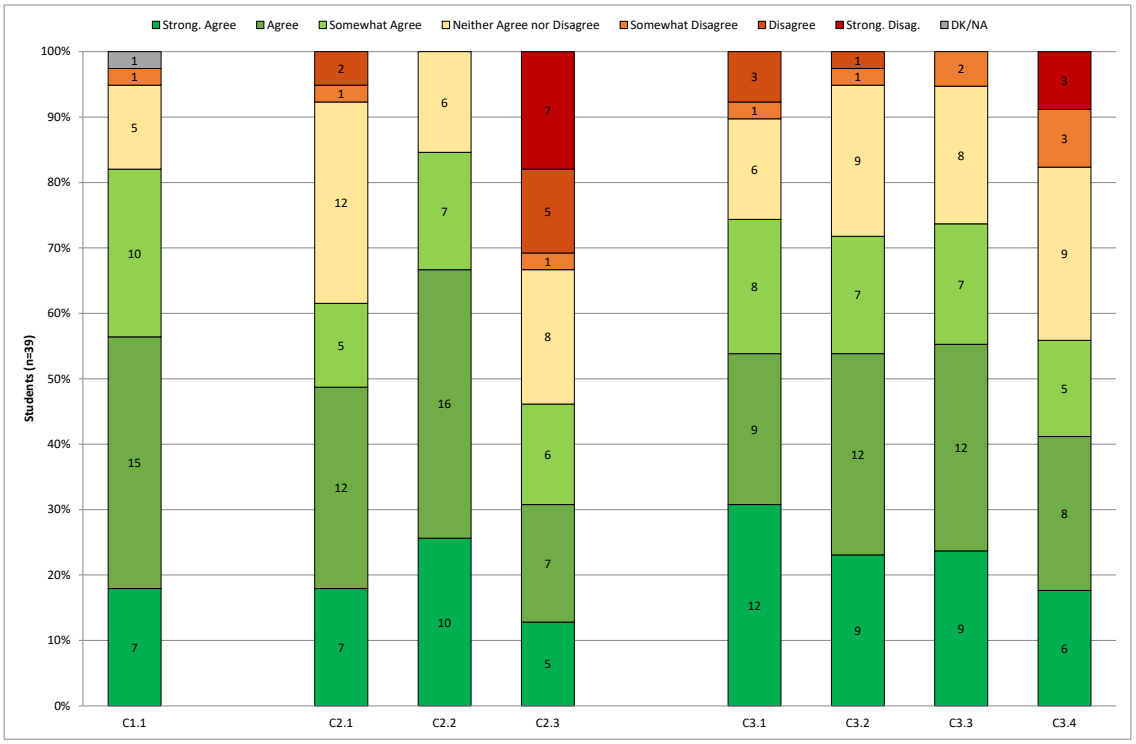


Figure 3.15: 100% stacked bars regarding the students' answers in CLaTMOOC final survey related to course badges. The questionnaire statements are described in Table 3.8.

	Statements
C1.1	Quizzes have been useful to learn new concepts about collaborative learning and/or ILDE
C2.1	I tried to earn badges because I liked to collect them
C2.2	I tried to earn badges because they showed my progression in the course
C2.3	I tried to earn badges because I competed with other students
C3.1	Trying to earn badges encouraged me to participate in the quizzes
C3.2	Trying to earn badges encouraged me to visit more pages of the course
C3.3	Trying to earn badges encouraged me to spend more time in the course
C3.4	Trying to earn badges encouraged me to interact with other students of the course

Table 3.8: Description of CLaTMOOC final questionnaire items related to course badges.

	T1.1 *(n=140)*	**T2.1** *(n=133)*	**T2.2** *(n=135)*	**T2.3** *(n=135)*	**T3.1** *(n=125)*	**T3.2** *(n=140)*	**T3.3** *(n=137)*	**T4.4** *(n=134)*
# Badges	0.532*	0.475*	0.517*	0.042	0.383*	0.462*	0.468*	0.400*
Avg. claim. time	-0.209*	-0.280*	-0.225*	0.119	-0.191	-0.256*	-0.267*	-0.151
Pageviews					0.343*			
Submitted tasks						0.393*		
Activity time							0.063	
Forum posts								0.279*

Table 3.9: Spearman's order-rank coefficient (ρ) between TraduMOOCv1 students' perceptions and the variables measuring student engagement [207].

gagement, and (C4) perceived effects of badges on student participation in the different type of activities. Figure 3.14 and Figure. 3.15 illustrates the details of the students' answers to each statement for TraduMOOCv1 and CLaTMOOC, respectively.

As displayed in both figures, students' perceptions toward badges were generally positive. First, students reported high influence of badges on their motivation to complete the activities (T1.1), and the positive benefits on learning of gamified quizzes (C1.1). Several answers in the final questionnaire supported the causality of the aforementioned correlations. For instance, *"I liked the game of badges because sometimes I didn't feel motivated to complete certain tasks but aiming to get the badge, encouraged me to do it"* or *"Badges encouraged me to keep participating in the course"*. Students' motivation to earn badges was mainly associated with their desire to collect them (T2.1 and C2.1) and to keep track of their progress (T2.2. and C2.2). The low degree of agreement in T2.3 and C2.3 indicates that competition with other students was not a principal motivation for earning badges although a leaderboard listing the earned badges was enabled in both courses.

Regarding the self-perceived effect of badges on behavioral engagement, students reported an influence of badges on the number of assignments (T3.1) and optional quizzes (C3.1) submitted, and to spend more time in the course (T3.3 and C3.3). Additionally, while most students disagreed with the impact of badges on visiting more course pages in TraduMOOCv1 (T3.2), most students in CLaTMOOC (71.79%) reported that badges encouraged them to visit more course pages. This difference could be explained due to conditions from CLaTMOOC badges were directly associated to learning contents (getting 100% score in quizzes) so students had to re-check the content pages before trying to earn the badges.

Finally, the T4 statements were particularly linked to the badges regarding TraduMOOCv1 quizzes, group activities, peer reviews, and the glossary activity. Based on the results, these badges encouraged students to participate in peer reviews (T4.1), quizzes (T4.2), and group activities (T4.3).

Perceptions toward Badges vs. Behavioral Engagement

According to the answers provided in the final questionnaire, most students had positive perceptions towards badges. However, we wanted to understand whether such perceptions actually corresponds to the effects produced on students' behavioral and reward-derived engagement. To this end, we correlated the variables measuring behavioral and reward-

	C1.1 *(n=38)*	**C2.1** *(n=39)*	**C2.2** *(n=39)*	**C2.3** *(n=39)*	**C3.1** *(n=39)*	**C3.2** *(n=39)*	**C3.3** *(n=39)*	**C3.4** *(n=39)*
# Badges	0.163	-0.006	0.184	0.247	0.235	0.185	0.098	0.343*
Avg. claim. time	0.178	0.184	-0.171	-0.075	-0.003	0.082	0.064	-0.092
Quiz particip.	0.248	0.117	0.361*	-0.011	0.361*	0.351*	0.127	0.119
Pageviews						0.150		
Activity time							-0.175	
Forum posts								0.129

Table 3.10: Spearman's order-rank coefficient (ρ) between CLaTMOOC students' perceptions and the variables measuring student engagement.

derived engagement with the answers provided in the final questionnaire by calculating the Spearman's order-rank coefficient (ρ) [191]. The Spearman's coefficient was selected due to the ordinal and non-numerical possible answers of the final questionnaire and the pre-calculated monotonic relationship between the correlated variables.

TraduMOOCv1 results (see Table 3.9) revealed a statistically significant positive moderate correlation between the number of badges earned and the reported motivation to earn them (ρ = 0.532), and between the number of badges earned and the following reasons: collecting them (ρ = 0.475) and progress indicators (ρ = 0.517). Additionally, we also found a statistically significant moderate correlation between the number of badges earned and the perceived effects of badges on student engagement (pageviews, submitted tasks, forum posts and activity time). This fact sustains that those students that earned more badges had a higher positive perception toward badges. A statistically significant negative low correlation was found between the average claiming time and the students' perceptions (T1.1, T2.1, T2.2, T3.2, T3.3). That is, students with positive perceptions toward badges, claimed and earned them earlier.

Conversely, CLaTMOOC results (see Table 3.10) showed non-significant statistical correlations between the number of badges earned and the different students' perceptions (except for C3.4). The high difficulty of badge conditions (100% score in quizzes) is posed as one main reason for such difference with the previous study. In order to confirm such assumption, students' perceptions were correlated with the number of submitted gamified quizzes, thus omitting the quiz difficulty effect. Results revealed a statistically significant low correlation between the number of quizzes and progression as a reason to earn badges (C2.2); between the number of quizzes and a higher participation in quizzes (C3.1), and between the number of quizzes and a higher number of pageviews (C3.2), as showed in the previous study.

Comparison between Students with Different Perceptions

Finally, behavioral and reward-derived engagement were compared between the students that reported negative (students answering *"I strongly disagree"* and *"I disagree"*; Group *No_Mot*, N=39) and positive (students answering *"I strongly agree"* and *"I agree"*; Group *Mot*, N=101) motivation caused by course badges to understand their differences on stu-

	Group No_Mot **Mean**	*Group Mot* **Mean**	**Mann-Whitney** (ρ)	**Effect size (r)**
# Badges	7.20	11.14	0.000*	-0.523
Avg. claiming time (days)	4.41	2.69	0.016*	-0.433
Pageviews	389.72	459.75	0.002*	0.000
Submitted tasks	10.26	12.70	0.000*	-0.060
Forum posts	2.41	3.45	0.002*	0.125
Activity time (h:m:s)	22:13:42	32:19:13	0.016*	0.408

** Correlation is significant at the 0.05 level (two-tailed)*

Table 3.11: U Statistic Mann-Whitney Test comparing student engagement between students that reported positive and negative motivation caused by badges [207].

dent engagement[11]. The *"I don't know/No answer"* answers were discarded from this analysis (N=13) because these students cannot be categorized into any of the previous categories. The Mann-Whitney test [196] was used to calculate statistical differences since (a) the dependent variables (*e.g.*, number of submitted tasks) are continuous; (b) the independent variables (*e.g.*, Mot and No_Mot) represent two independent categorical groups with independence on its observations; and (c) the observations follow a similar distribution shape.

Results (see Table 3.11) show a statistically significant difference for every variable (ρ<0.05) measuring engagement. These differences reveals that Group *Mot*, on average, earned more badges (11.14 *vs.* 7.20) whose claiming time was shorter (2.69 *vs.* 4.41 days), and had a higher behavioral engagement than the Group *No_Mot*: pageviews (459.75 *vs.* 189.72), number of submitted tasks (12.70 *vs.* 10.26), number of forum posts (3.45 *vs.* 2.41) activity time (32h:19min *vs.* 22h:13min). Additionally, the large effect size (r)[12] of reward-derived engagement (-0,523 and -0,433, number of badges and average claiming time span respectively) confirms such significant difference on reward-derived engagement between both groups. Therefore, those students that perceived positive motivational effects caused by badges, had a higher engagement level than the students who perceived them as negative for motivation.

3.3.7 Limitations

The empirical studies presented in this section had some limitations. The first limitation refers to the topic and target population of the empirical studies. Each study was focused on a course from a specific discipline (*i.e.*, translation and collaborative learning) and had a specific target population, and therefore its findings are of limited generalizability to other contexts. Nevertheless, these two empirical studies contribute to the reduced body of research about gamification in MOOCs with a deep understanding on how some

[11] This analysis was restricted to TraduMOOCv1 due to the low number of participants that submitted the final questionnaire in CLaTMOOC (N=39).

[12] According to Mangiafico (2016) [176], effect size refers to *"the degree to which one group has data with higher ranks than the other group, being related to the probability that a value from one group will be greater than a value from the other group (without being affected by sample size)"*.

types of reward-based strategies (*i.e.*, badge achievements and course privileges) affect to student engagement. Additionally, the number of enrollments in both courses was low (1031 and 632) as compared with mainstreamed MOOCs reaching up to 10k enrollments. Future work should understand whether the gamification effect reported in these studies is also observed in such mainstreamed MOOCs. Nevertheless, it is worth mentioning that many MOOCs have similar enrollment rates as the TraduMOOCv1 and CLaTMOOC had [134].

The second limitation refers to those students that abandoned the course during the intermediate modules. Although these students were considered for the engagement-related analysis, their perceptions toward badges were not collected in the final questionnaire of the course. Therefore, students' perceptions gathered in both studies partly represent the population of the implemented MOOCs. Perceptions from those students abandoning during the intermediate weeks could provide useful hints to help align reward-based strategies to avoid student drop out. As a future work, it would be interesting to weekly ask participants about their reward perceptions, or even right before unsubscribing from the course. Additionally, we also plan to collect students' initial motivation (regardless of course rewards) to better understand the motivational effects of rewards during the course and classify them according to the different 'motivational profiles' enrolling in MOOCs. Short pre- and post- questionnaires measuring student motivation in instructional settings such as the Instructional Materials Motivation Survey (IMMS) [171] could help collect all this information in our future studies.

The third limitation refers to the gamification design of the course. Reward-based strategies are usually formed by two main components: the rewards (including their type and signifier) and the conditions under which such rewards are issued. In the two empirical studies reported in this section, we only implemented badge achievements as rewards that were issued when the predefined conditions were satisfied. Therefore, although the results reported in this section can be framed within the concept of 'reward-based strategies', it is interesting to understand whether they can be generalizable to other types of rewards (*e.g.*, experience points, levels).

Finally, TraduMOOCv1 practitioners wanted to implement more complex conditions and gamify actions performed in external tools such as Facebook or Google Forms. Due to the current limitations of commercial tools we were forced to redesign the course gamification, for example, by making students 're-submit' a summary of the task in a Canvas Network assignment. These decisions (*e.g.*, re-submission of activities from course participants) could have had an impact on student engagement that was omitted.

3.3.8 Discussion

In spite of the limitations presented before, the two studies reported in this section represented our first experience using gamification in real MOOC environments. Their associated analysis helped us gather initial evidence about the effects of reward-based strategies in real heterogeneous sets of participants enrolled in MOOCs.

Results showed that reward-based strategies had a positive impact on student behavioral and reward-derived engagement. More concretely, moderate statistically significant correlations were found between certain variables measuring behavioral engagement and

variables measuring interest on badges. This positive effect was also observed in the student answers provided in the final questionnaire. Additionally, students that reported to be motivated by the possibility of earning badges presented a higher behavioral engagement (see Table 3.11). Nevertheless, it was observed that the effect of reward strategies on participation in gamified activities was much higher during the first two weeks of the MOOC and then decreased. This fact was observed in (a) the students participating in gamified tasks; (b) in Group B students, who earned the first badges and then stopped earning rewards; and, (c) in the increasing claiming time span throughout the course.

Results also showed a general positive perception toward reward strategies among the students that were active until the end of the course. Both studies revealed that most participants reported progression and collection as the main reason to collect course badges, and that course rewards increased their behavioral engagement within the course. On the other hand, competition was identified as the least reported reason to achieve badges.

Regarding TraduMOOCv1, learners were classified according to their reward-derived engagement. According to the results, while certain students were motivated by the possibility of earning badges during the whole course, others showed an initial interest during the first weeks, and some others did not earn any badge. In our study, the number of students achieving many badges was relatively high as compared with those students earning few badges. Additionally, the proportion of students reporting to feel motivated by badges was more than the double of those students that were not motivated. Therefore, practitioners should design reward-based strategies targeting to the different learners' profile and avoiding bother those students disinterested on course rewards.

Regarding CLaTMOOCm results suggested that differences in quiz configurations can potentially affect the students' reward-derived engagement. Collaborative quizzes presented an important decrease of participation as compared with the other gamified quizzes and with the active students per module. Quizzes configured with 3 attempts encouraged students to participate and get the maximum score as compared with those with one single attempt. Conversely, the quiz incorporating a 3-minute timer, did not experience high differences on quiz participation, completion and badge request as compared with the other course quizzes. As a future work, it could be interesting to understand whether other quiz parameters such as the number of questions or the form that collaborative quizzes are implemented affect to students' reward-derived engagement. Therefore, information about the important parameters affecting students' reward-derived engagement could be useful for practitioners to configure challenging gamified quizzes.

3.4 Comparing the Effects of Reward-Based Strategies on Student Engagement

The third case study was carried out in 2018, having already developed a first version of the GamiTool prototype (one of the contributions of this dissertation). This fact allowed us implement more complex gamified learning designs including traditional (*e.g.*, badges) and redeemable reward (*i.e.*, course privileges) strategies. Therefore, we designed this study to further investigate the effects of reward-based strategies on student retention, engagement and participation, and to compare the effect of these two different types of

rewards.

The generic research question that led this study was *RQ2. To what extent reward-based strategies foster student retention, engagement and reward-derived engagement in MOOCs?* To help answer this research question, we performed a between-subjects study design [44] to be applied in the second run of the TraduMOOC. In this context, GamiTool also allowed to apply a simple random process, assigning participants to one control (CTRL, without reward-based strategies) and two experimental conditions: Badges (BADGE) and Redeemable Rewards (REDEEM).

3.4.1 Context

The study was conducted in the second run of the aforementioned MOOC on translation from English to Spanish in the business and economical fields (see Sec. 3.3.1). The course was offered by University of Valladolid from March, 12th to May, 6th, 2018 (8 weeks) in the Canvas Network platform. Similarly to the first run, the content was divided into 7 weekly modules plus one extra week to complete the activities. Course activities and assignments were similar to the previous run, although some changes were made by the leading instructor according to the feedback gathered from the previous version. The modules included videos, learning content pages, recommended readings, discussion forums and individual and collaborative activities (see Fig. 3.16). Further information about the course context is described in Section 3.3.1.

3.4.2 Gamification Design and Instantiation

Gamification was designed between researchers and the main instructor of the course in a co-design session [215]. Before co-design, the instructor was encouraged to conceptualize the student behaviors that she considered beneficial for their learning and the potential privileges that could be rewarded to students (see Fig. 3.18). Additionally, those rewards that showed higher reward-derived engagement in the previous run (*e.g.*, high score in quizzes) were also considered. All together, the main instructor and the researchers agreed on the final gamification design according to the capabilities of the MOOC and gamification platform. The resulting gamification design (including badges and redeemable rewards) is presented in Figure 3.17.

The gamification design was digitally represented and implemented with GamiTool, one of the contributions of this dissertation that will be introduced in the next chapter. The student information transferred between Canvas Network and GamiTool through IMS LTI allowed GamiTool to distinguish the learner condition, and to display a different interface for each group as shown in Figure 3.19. Therefore, the course content (pages, assignments, *etc.*) was common to all participants, and only the gamification tab was different for learners belonging to different groups.

In this study, rewards were implemented to be explicitly claimed with a button by MOOC participants with a two-fold purpose. First, with this button, learners interested to earn rewards can be distinguished from those only interested on completing the optional activities. Second, the button allows learners that are not interested or attracted by rewards to avoid being bothered by them. This claiming approach provided us with extra variables

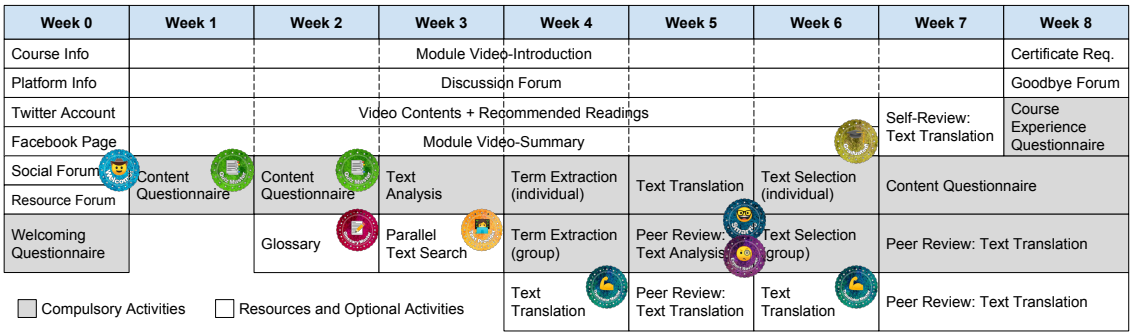


Figure 3.16: TraduMOOCv2 learning design [206].

Group BADGE

Group REDEEM

Week Cond.	Image	Name	Condition	Privilege	Week Priv.
0		*Welcome!*	Update your profile picture and introduce yourself in the Social Forum	Get 3 more attempts in Quiz 1 and Quiz 2	1, 2
1, 2		*Quiz Master!*	Get a score, equal or higher than 90% in Quiz 1 and Quiz 2	Get access to extra content in week 2	2
2		*Glossary Master!*	Contribute with at least 3 terms in the Glossary activity	Extend the due date of the compulsory task at week 3	3
3		*Text Provider!*	Share a text in the Parallel Text Search activity and receive 5 likes from other participants	Extend the due date of the text translation task at week 5	5
5		*Expert Reviewer!*	Review 2 more submissions from your colleagues (4 in total) in week 5	Join the queue so that the instructors evaluate your work and provide feedback	5
5		*Smartie!*	Get a score, equal or higher than 70% in the reviews performed by other peers regarding your submission	Get 20 more minutes in Quiz 7	7
4, 6		*Translation Master!*	Submit the optional translations: Public Descriptive text and Expositive Private text	Get 3 more attempts in Quiz 7	7
6		*Graduated!*	Watch the "summary videos" in weeks 1 to 6	Get access to an exclusive video-session with the teacher and other students	7

Figure 3.17: TraduMOOCv2 gamification design [206].

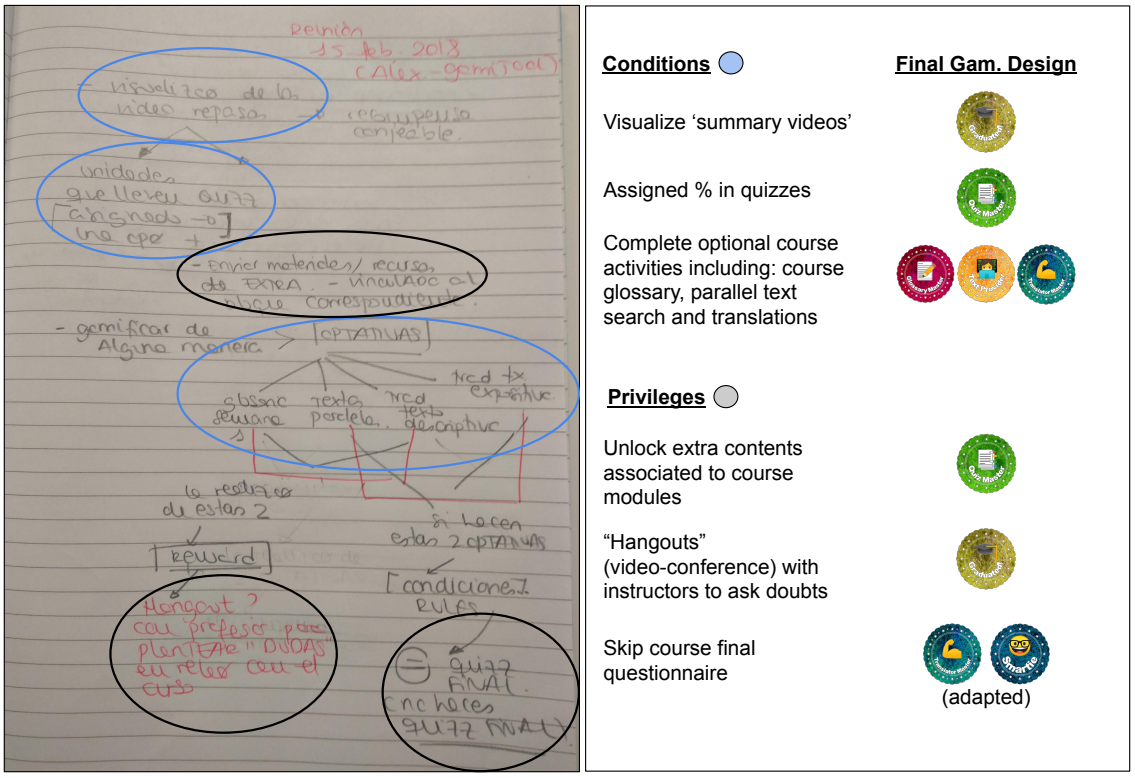


Figure 3.18: Part of the conceptualized gamification design expressed by the main instructor of the course before the co-design session.

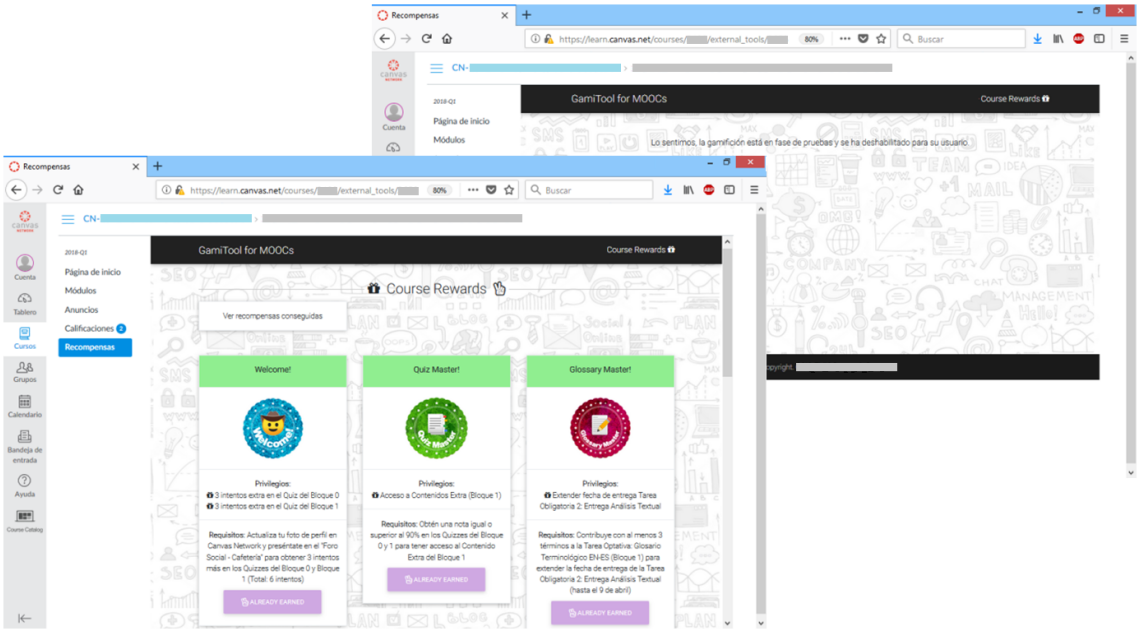


Figure 3.19: "Rewards" tab for the students belonging to the REDEEM (left) and CTRL (right) groups [206].

to measure the reward-derived student engagement (*e.g.*, variables measuring whether the student claimed the rewards right after satisfying the conditions). Finally, researchers decided to make each one's rewards only visible for each specific learner (*i.e.*, students could not share with other students the rewards earned). Therefore, the possible behavioral effects caused by social comparison were avoided [89].

3.4.3 Methodology and Data Sources

The underlying research question guiding this study was *RQ2. To what extent reward-based strategies foster student retention, engagement and reward-derived engagement in MOOCs?* To help answer this research question, we performed a group-comparison experimental design (between-subjects study design) [44] to better understand the causality relationship between student retention, engagement and reward-derived engagement.

According to the gamification benefits shown in the previous chapter, we hypothesized that students involved in the experimental conditions (BADGE and REDEEM) would show a higher retention level, behavioral engagement and task participation. Additionally, we believe that redeemable reward strategies would create a higher reward-derived engagement than badge strategies due to the associated course privilege. Consequently, the following null hypotheses were formulated:

H_O1. *Student retention level is the same when badges are available, when redeemable rewards are available, and when neither of them is available.*

H_O2. *Student behavioral engagement level is the same when badges are available, when redeemable rewards are available, and when neither of them is available.*

H_O3. *The percentage of students that satisfy the conditions associated to rewards is the same when badges are available, when redeemable rewards are available, and when neither of them is available.*

H_O4. *The time employed by students to satisfy the conditions associated to rewards is the same when badges are available, when redeemable rewards are available, and when neither of them is available.*

H_O5. *Rewards are claimed the same time after the conditions are satisfied by the students when badges are available and when redeemable rewards are available.*

As analyzed in previous empirical studies, we further investigated the student general perceptions toward reward-based strategies including information about the preferred and least liked rewards.

In order to help answer the posed research questions and test the stated hypotheses, this study employed multiple data sources:

- **Canvas Log.** Registry of learner actions performed in the MOOC platform. This registry includes student engagement information such as the number of pageviews, the tasks submitted and the number of forum posts.
- **GamiTool Log.** Registry of student actions performed in the gamification platform such as the number of rewards issued and the time stamps.

Hypotheses/ Substudies	Variables	Sources	Tests
Group homogeneity	Initial questionnaire variables	Canvas Pre-Quest	Chi-square Test
H_O1. Retention	Percentage of learners visiting the course, submitting compulsory tasks and obtaining the course certificate	Canvas Log	2-Proportion Z-Test
H_O2. Behavioral engagement	Pageviews, compulsory submissions, forum posts, activity time	Canvas Log	Z-Test
H_O3. Fulfillment of conditions	Percentage of learners satisfying the reward conditions	Canvas Log	Wilcoxon Signed-Rank Test
H_O4. Fulfillment of conditions	Timestamps when conditions associated to rewards are satisfied	Canvas Log	Wilcoxon Signed-Rank Test
H_O5. Request of rewards	Timestamps when rewards are claimed and issued	GamiTool Log	Wilcoxon Signed-Rank Test
Rewards perceptions	Participants satisfying the reward conditions and their self-reported experience with rewards	Canvas Log Canvas Post-Quest	-

Table 3.12: Summary of the data analysis [206].

- **Canvas Pre-Quest.** Information retrieved from the MOOC platform containing the answers provided to the initial questionnaire (*e.g.*, age, location, background, previous experience with MOOCs).
- **Canvas Post-Quest.** Information retrieved from the MOOC platform containing the answers provided to the last-module questionnaire. The questionnaire contained two open-answer questions regarding participants' perception about course rewards: (a) most and least liked rewards, and (b) general impression of course rewards. These questions were only visible for participants belonging to the experimental conditions.

Data sources included both quantitative (*e.g.*, Canvas Log) and qualitative (*e.g.*, Canvas Post-Quest) information. Further information about the evaluation questionnaire used in this study can be found in Appendix A. Questionnaires' content-related evidence of validity (*i.e.*, definition, sample, content and format) [94] was obtained by three TEL research experts from GSIC-EMIC group.

The student retention [Hypothesis H_O1] was measured through three different variables: (i) the number of learners that submitted the compulsory weekly task in the intermediate and last weeks of the course, (ii) the number of learners that visited at least one page in the intermediate and last weeks of the course, and (iii) the number of learners that obtained the course certificate [143]. Pairwise *two-proportion z-tests* [196] were performed to identify significant differences between conditions in the proportion of learners satisfying the previous variables in relation with the number of learners that started the course.

Behavioral engagement [H_O2] was calculated through four variables typically used to this end in the literature ([121, 87]): the number of pageviews, the number of submitted tasks, the number of forum posts and the total activity time registered at the end of the

course. Pairwise *z-tests* were calculated to analyze the mean differences of the previous variables between conditions due to the large sample sizes [196].

Reward-derived engagement [H_O3][H_O4][H_O5] was analyzed considering the percentage of active learners satisfying the conditions associated to rewards, the percentage of learners claiming the rewards, and the timestamps of both actions (satisfying the conditions and claiming the rewards). In this context, *Wilcoxon signed-rank tests* [196] were calculated to compare the differences among the three conditions. This test requires that differences between paired samples should be continuous and distributed symmetrically around the median. However, the presence of outliers on either side makes reasonable to assume that the population is approximately symmetric for the three variables [196]. Additionally, we have calculated the effect size to isolate the mean difference sizes [51]. All the previous data (see Table 3.12) was gathered together in a Microsoft Excel[13] worksheet and processed with the RStudio software[14].

Besides, participants were provided with a questionnaire (compulsory to obtain the course certificate) in the last week of the course (see *Canvas Post-Quest.* data source). Learners' answers were classified into several categories following an open coding scheme[15] [247] to obtain some insights that can be useful for the design of future reward-based strategies in MOOCs.

3.4.4 Participants

A total number of 866 learners enrolled in the course[16], out of which 648 submitted the initial questionnaire, thus getting access to course contents and activities (see Table 3.13). According to the data reported in the initial questionnaire (see Fig. 3.20), the students of this study were mostly female (83.02%), between 20-30 years old (64.17%), from Latin America (53.86%), with an undergraduate background (56.17%), and medium knowledge level about the topic of the MOOC (39.81%), planning to actively participate in the course (58.64%), without previous MOOC and gamification experience (69.60% and 60.49% respectively), and with positive beliefs about the benefits of using gamification in educational environments (64.20%).

Attending to the between-subjects study design, students were assigned to one of the three conditions of the study once they enrolled in the course.

- **BADGE:** Students involved in this condition were able to obtain up to 8 badges throughout the course.
- **REDEEM:** Students involved in this condition were able to obtain up to 8 redeemable rewards whose requirements were the same as the badges.
- **CTRL:** Students involved in this condition had neither rewards nor game elements implemented in the course. This condition was considered as the control group of

[13] Microsoft Excel: *https://products.office.com/*, last access: September, 2019.

[14] RStudio: *https://www.rstudio.com/*, last access: September, 2019.

[15] According to Saldaña (2015), *coding* refers to a method that enables organize and group similarly coded data into categories or families sharing similar characteristics [247]. Categories, codes and coded information can therefore help consolidate meanings and explanations [247].

[16] A simple random process was applied to assign participants to the different conditions but the number of enrolled students in every condition is different due to the removal of test users and duplicated accounts.

Condition	Course Enrollments	Participants of the Study
BADGE	290	223
REDEEM	287	205
CTRL	289	220
Total	866	648

Table 3.13: Number of enrollments and participants of the study per condition [206].

Variable	*p-value*	**Exclusions** (number of answers)
Age	0.954	DK/NA (2): R (1), C (1)
Gender	0.914	DK/NA (3): B (1), R (1), C (1)
Background	0.121	DK/NA (2): R (1), C (1)
Location	0.875	Asia (2), DK/NA (2): R (2), C (2)
Topic Knowledge level	0.531	None (13), DK/NA (2): B (6), R (3), C (6)
Participant type	0.836	-
MOOC experience	0.928	DK/NA (2): R (1), C (1)
Gamification experience	0.573	-
Gamification beliefs	0.249	-

Table 3.14: Chi-square test for homogeneity *p-values* regarding the variables of the initial questionnaire (DK/NA= Don't Know/No Answer; [B] ADGE, [R] EDEEM, [C] TRL). *P-value* is significant at $<.05$ level (two-tailed) [206].

the study.

By using the enrollment date to assign students to the different conditions avoided bias caused by late-registration students who are more likely to disengage with the course [104]. Additionally, learners were not informed of the existence of other groups in order to avoid unexpected behaviors caused by the desire to belong to other groups.

Before testing the hypotheses of this study, we checked the homogeneity of the three conditions regarding the variables of the initial questionnaire including the student gender, age, background knowledge level and type of participation in the course. If groups are homogeneously distributed, the differences in the composition of the groups are not likely to influence the results of the study. To this end, we have conducted a *Chi-square homogeneity test* [147] for every variable considered in the initial questionnaire[17] The Chi-square test was selected due to *(i)* the categorical values of the questionnaire variables (*e.g.*, location, gender) and the conditions (*i.e.*, BADGE, REDEEM, CTRL), and *(ii)* the randomized sampling method followed to assign the students to the groups.

According to the results (see Table 3.14), the *p-values* are much higher than the significance level (.05) for every variable. Therefore, the degree of similarity among groups

[17]The Chi-homogeneity test assumes a minimum number of frequencies of every multiple choice option (freq.$>$5). In our case, some questions were answered with a frequency under this value. As a consequence, these values have been removed or grouped as *other answer* representing a maximum number of 15 excluded answers among the three groups (*i.e.*, 2.31% from the total number of answers) as described in Table 3.14.

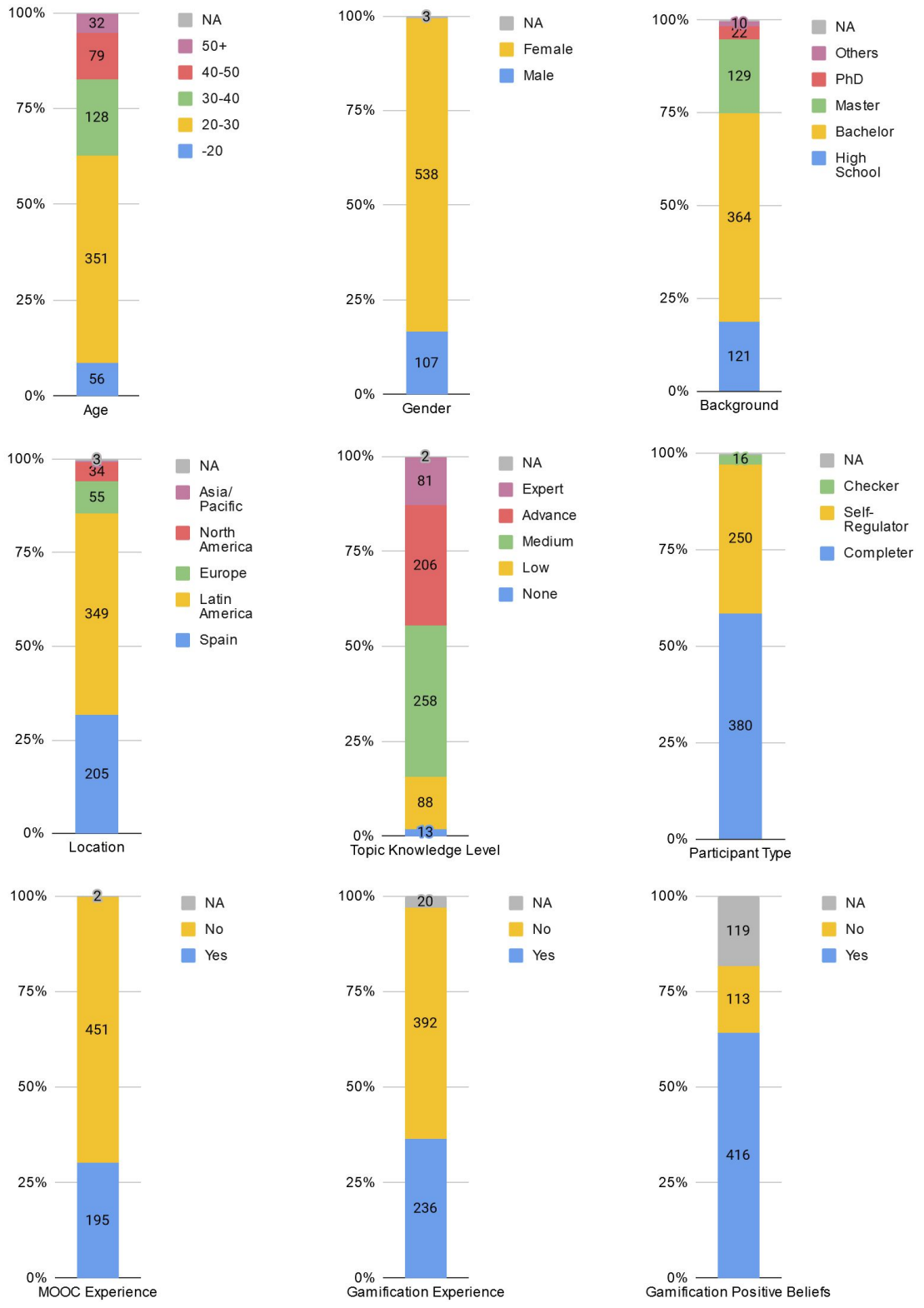


Figure 3.20: MOOC participants' demographic information (N=648).

	BADGE	REDEEM	CTRL	*p-value*
Initial Questionnaire	223 (34.41%)	205 (31.64%)	220 (33.95%)	
Visited interm.	119 (33.71%)	112 (31.73%)	122 (34.56%)	0.956
Visited last	88 (36.06%)	68 (27.87%)	88 (36.06%)	0.446
Submitted interm.	67 (34.71%)	59 (30.57%)	67 (34.71%)	0.947
Submitted last	67 (36.02%)	55 (29.57%)	64 (34.41%)	0.817
Certified	63 (37.06%)	49 (28.82%)	58 (34.12%)	0.679

Table 3.15: Descriptive statistics of variables measuring student retention including the *p-value* Chi-square goodness of fit test. *P-value* is significant at $<.05$ level (two-tailed) [206].

regarding the variables measured in the initial questionnaire is high and the results obtained in this study are unlikely to be caused by the composition of the groups.

3.4.5 Results

H_O1. Student Retention

Null hypothesis 1 states that *student retention will be the same in three conditions of the study*. To examine this hypothesis, we measured the number of *(a)* certified learners, *(b)* learners submitting the intermediate and last compulsory assignment, and *(c)* learners visiting the course in the intermediate and last week, in proportion to the learners that submitted the initial questionnaire.

Results (see Table 3.15) show that all p-values calculated for the different variables measuring student retention are higher than the significance level (.05). The high p-values and the similar proportions indicate that the evolution of active participants throughout the course was very similar for the three groups. Therefore, H_O1 cannot be rejected.

H_O2. Student Behavioral Engagement

Null hypothesis 2 poses that *student behavioral engagement will be the same in the three conditions of the study*. To test this hypothesis, we analyzed the number of pageviews, tasks submitted (optional and compulsory), forum posts (entries and replies), and the total activity time (in minutes). In order to avoid bias caused by students that enrolled in the course without intention to finish it, two clusters of students were considered: *(a)* students who submitted the initial questionnaire excluding *Samplers* and *Strong Starters*[18] [150, 87], and, *(b)* students who were active until the end of the course, considering only *Late* and *Keen Completers*[19] [150, 87]. Results are presented in Table 3.16 for both clusters (see left and right columns respectively).

With all the data gathered, we conducted pairwise z-tests (two-tailed, *alpha* = .05) between the three conditions according to the four variables described before (for the two

[18] *Samplers* are those learners who visit course content during a very small number of weeks, in this case, the first two weeks. *Strong Starters* are those learners that completed the first compulsory activity but then dropped out the course.

[19] *Late Completers* are those learners who completed the last compulsory task and submitted most of other assessments, but were either late or missed some out. *Keen Completers* are learners who completed all the compulsory activities, engaging actively throughout the whole course.

	C1: Excluded Samplers and Strong Starters			C2: Late and Keen Completers		
	BADGE (N=127)	REDEEM (N=112)	CTRL (N=123)	BADGE (N=66)	REDEEM (N=54)	CTRL (N=60)
Pageviews						
Median	388	310	299	574.5	590	561.5
Mean	439.4	406.3	386.5	614.7	660.6	615.5
Std	375.91	345.92	320.39	240.12	342.88	316.09
Task Submissions						
Median	10	6	8	12	12	12
Mean	7.945	7.33	7.602	12.35	11.98	12.17
Std	4.80	4.71	4.68	1.36	1.64	1.22
Forum Posts						
Median	1	1	1	1	1	1
Mean	1.803	1.821	1.22	2.727	2.796	1.717
Std	4.24	2.93	1.81	5.67	3.90	2.19
Activity Time*						
Median	731.4	710.59	810.32	1101.3	1306.5	1085.1
Mean	1134.4	1019.93	1255.28	1545.1	1465.2	1775.6
Std	1242.65	888.93	1624.26	1375.93	954.97	1968.55

Table 3.16: Median, mean and standard deviation values for variables measuring student behavioral engagement regarding the first (left) and the second (right) clusters. *Participants unregistering before the course end were not considered (15, 14, 14 participants in C1 from BADGE, REDEEM and CTRL respectively, and 1 participant in C2 from the BADGE condition) [206].

	C1: Excluded samplers and strong starters			C2: Late and keen completers		
	BADGE VS. CTRL	REDEEM VS. CTRL	BADGE VS. REDEEM	BADGE VS. CTRL	REDEEM VS. CTRL	BADGE VS. REDEEM
Pageviews	0.230	0.649	0.479	0.986	0.467	0.405
Task Submissions	0.567	0.658	0.318	0.430	0.499	0.189
Forum Posts	0.155	0.061	0.969	0.18	0.072	0.937
Activity Time	0.535	0.190	0.439	0.451	0.277	0.710

Table 3.17: Z-test *p-values* of variables measuring student behavioral engagement between conditions for the first (left) and second (right) clusters. *P-value* is significant at the $<.05$ level, two-tailed [206].

	BADGE			REDEEM			CTRL		
	N	*%*	**Date** (μ)	*N*	*%*	**Date** (μ)	*N*	*%*	**Date** (μ)
Welcome	72	36.73	17/03 01:07:51	70	36.65	15/03 00:38:35	41	20.30	15/03 03:54:19
Quiz	51	30.18	25/03 04:01:14	40	27.78	24/03 23:52:21	35	22.01	24/03 18:39:56
Glossary	28	16.57	26/03 13:48:40	39	27.08	25/03 23:17:24	17	10.69	24/03 21:43:41
Text Prov.*	17	12.32	03/04 05:31:49	22	18.49	03/04 12:43:41	17	12.88	02/04 14:42:26
Reviewer	53	57.61	13/04 00:54:20	45	52.33	13/04 19:12:00	43	43	13/04 09:29:18
Smartie*	69	75	12/04 18:49:49	56	65.12	12/04 21:11:28	67	67	12/04 08:29:51
Translation	12	15.58	23/04 13:38:08	7	9.72	23/04 10:27:10	6	7.69	21/04 20:14:47
Graduated	35	45.45	21/04 17:21:38	30	41.67	22/04 10:39:41	22	28.20	18/04 18:22:48

Table 3.18: Statistical summary of participants satisfying the reward conditions (number and percentage of participants in relation with the number of active students per week, and mean value for the date and time of completion). *Rewards whose conditions' satisfaction depended on course peers instead on the own learner [206].

clusters). Results (see Table 3.17) revealed that there is a tendency towards significance in the number of forum posts between the REDEEM and the CTRL group in both clusters (on average, 0.6 and 1 forum posts higher in C1 and C2 respectively). However, the *p-values* are higher than the threshold level for every variable measuring student engagement in both clusters. Therefore, H_O2 cannot be rejected.

H_O3. Reward-derived Engagement: Student Participation

Null hypothesis 3 predicts that *conditions associated to rewards will be satisfied by the same percentage of students in the different groups of the study*. The list of percentage completion for each reward is presented in Table 3.18.

After performing a Wilcoxon signed-rank test, the *R*- value obtained when comparing the BADGE and REDEEM group with the CTRL group is 1 for both groups, which is under the critical value = 3 (two-tailed, alpha=.05, n=8) [196]. We can conclude that the median weights of the percentage of students satisfying the gamified-task conditions in the BADGE and REDEEM groups (36.18% and 34.85% respectively) are statistically significantly different from the median weight in the Control group (26.47%) with a *p-value* of 0.016. Additionally, the effect size is approximately 0.586 for the BADGE and REDEEM conditions, which is very large according to Cohen's classification of effect sizes for *behavioral sciences* [51]. Results also showed an absence of statistically significant differences between the BADGE and REDEEM groups (*p-value* = 0.641).

According to the results, both experimental groups present significant differences with the CTRL group regarding the percentage of students satisfying the gamified-task conditions (9.71% and 8.38% difference for the BADGE and REDEEM groups respectively).

Therefore, H_O3 is rejected, and can be concluded that a significantly higher percentage of students in the experimental groups (REDEEM and BADGE) satisfied the gamified conditions in comparison with the CTRL group.

H_O4. Reward-derived Engagement: Condition Completion Time

Null hypothesis 4 poses that *conditions associated to rewards will be satisfied at the same moment in the different conditions of the study*. Mean values of condition completion dates are presented in Table 3.18.

After performing a Wilcoxon signed-rank test, the *R*- value obtained when comparing the BADGE and REDEEM group with the CRTL group is 1 in both cases, which is over the critical value = 0 (two-tailed, alpha=.05, n=6[20]) [196]. Therefore, we can conclude that the median weights of the dates when students satisfy the gamified-task conditions in the BADGE and REDEEM groups are close to be significantly different from the median weight in the CTRL group (1 day, 9 hours and 4 minutes, and 1 day, 3 hours and 17 minutes later, respectively) with a *p-value* of 0.062 for both groups. Furthermore, there are not statistically significant differences between the median weights of the dates that students satisfied the reward conditions in the BADGE and REDEEM groups (*p-value* = 0.844).

Results showed that students in the control group performed the gamified tasks earlier than the students in both experimental groups. However, this difference is not statistically significant and therefore, H_O4 cannot be rejected.

H_O5. Reward-derived Engagement: Reward Request Time

Null hypothesis 5 states that *rewards will be claimed at the same time in the experimental conditions of the study (REDEEM, BADGE)*. The statistical summary of claiming dates is presented in Table 3.19.

After performing a Wilcoxon signed-rank test, the *R*- value obtained when comparing the BADGE with the REDEEM group is 1, which is under the critical value = 3 (two-tailed, alpha=.05, n=8) [196]. Therefore, we can conclude that the median weight of the dates when students claimed and earned the gamified-task conditions in the BADGE group is significantly different from the median weight in the REDEEM group (17 hours, 55 minutes and 4 seconds later) with a *p-value* of 0.016 and a very large effect size (r = 0.604) [51].

According to the results, students from the REDEEM group claimed the rewards significantly earlier than those students from the BADGE group. Therefore, H_O5 is rejected, and can be concluded that students in the REDEEM condition claimed and earned the rewards sooner (17 hours, 55 minutes and 4 seconds) than the students in the BADGE condition.

	BADGE			REDEEM		
	N	*%*	**Date** (μ)	*N*	*%*	**Date** (μ)
Welcome	56	77.78	23/03 22:08:27	56	80	20/03 03:01:47
Quiz	33	64.71	31/03 00:49:54	31	77.5	27/03 20:13:57
Glossary	25	89.29	27/03 15:47:03	32	82.05	26/03 23:54:53
Text Prov.	14	82.35	07/04 11:15:09	19	86.36	07/04 15:38:37
Reviewer	33	62.26	17/04 12:21:20	23	51.11	15/04 20:07:43
Smartie	41	59.42	20/04 19:51:15	29	51.79	17/04 11:57:25
Translator	10	83.33	25/04 18:09:09	5	71.43	23/04 22:11:50
Graduated	29	82.86	25/04 11:55:54	19	63.33	23/04 04:30:04

Table 3.19: Statistical summary of participants claiming and earning course rewards [206].

Student Perceptions toward Rewards

Table 3.19 shows the percentage of learners that were issued with rewards with respect to the number of students that satisfied the conditions. Rewards were earned by more than 50% of learners in both experimental conditions (BADGE and REDEEM) which shows certain interest of students toward earning them. However, depending on the particular condition, the top three most claimed rewards were different: *Glossary Master*, *Translator Master*, and *Graduated* in the BADGE condition, and *Text Provider*, *Glossary Master*, and *Welcome* in the REDEEM one.

In order to further understand these results, participants' open answers in the final questionnaire were classified following an open-coding scheme [247]. 17 participants (out of 53) in the BADGE condition (see Table 3.20) showed a general positive attitude to all rewards, 13 expressed the no attainment of rewards, and 7 participants highlighted *Translator Master* badge as the favorite reward due to the benefits of translating texts. 8 students underlined the lack of time to complete optional tasks as the ones involving rewards, and 7 students pointed at *Welcome* and/or *Text Provider* as the least engaging badges due to the easiness of the condition and the necessity to share comments with other peers in order to earn them. Finally, 3 learners indicated the potential usefulness of redeemable rewards in this type of courses.

In the REDEEM condition (see Table 3.21), it is noteworthy that in the open-ended answers, learners named the rewards according to their associated privilege (*e.g.*, *access to extra content* instead of *Quiz Provider*). This fact suggests a higher interest on course

[20] In this hypothesis testing, we have removed the tasks associated to *Text Provider* and *Smartie* rewards because the fulfillment of the conditions depended on peers actions and not in the own student.

Group BADGE (53 participants)		
Perceptions	**N**	**Excerpts of Evidence**
General positive attitude to all rewards in general	17	*"I think that all the rewards were adequate for each activity, aiming to strengthen the lessons of each module."* *"I think I liked all rewards because they motivated me to perform the different tasks, and to look forward the upcoming module."* *"Generally speaking, I liked earning the rewards, since it motivated me to do the optional activities. By working with the optional activities, I got more feedback and therefore I could evaluate my own performance and progress [...]"*
No attainment of rewards	13	*"I was not paying attention to rewards. When I decided to earn the first one, I realized it was already late."* *"I was not aware of the rewards."* *"I haven't intended to earn any, but I find them as a good idea."*
Lack of time to complete optional tasks as those involving rewards	8	*"I didn't have time to complete (the conditions to earn) the rewards, but I find them as a good initiative."* *"The truth is that I started wanting to complete the exercises that led to the rewards, but due to lack of time it was impossible."* *"Although I did not choose to do any, I found the optional activities very interesting. It is a way of reward the "extra" time and work that the learner dedicates to the course. I would like to have done them, [..]. Unfortunately, due to time issues I couldn't."*
Translation Master as the favorite reward	7	*"In general, I liked all of them, especially the Translation Master one, but unfortunately I did not earn it :("* *"(I liked most) The Text Provider and Translation Master rewards as they involve research work. [..]"* *"I liked more those rewards associated to text translation, because they motivated me to complete those tasks [..]"*
Welcome and/or *Text Provider* as the least engaging rewards	7	*"[..] I did not like the ones that required sharing with colleagues in the forums. I am an introverted person and it bothers me to have to communicate in forums with people I don't know."* *"I did not like the first one that you had to present yourself in the social forum. It seems to me that the rewards should be more related to the content and the activities of the course rather than to the social aspect [..]"* *"[..] The reward I liked the least was the one related with the parallel text because it seemed very easy and without much sense; just with a quick search on the Internet you get all the texts you want."*
More interest on rewards if they have associated privileges	3	*"I had only few rewards, I did not feel motivated to obtain them. It would be interesting if the rewards were points to improve tests or tasks with evaluation."* *"I like all of them, although perhaps more incentives should have been added. I am not sure what, but it would improve participation."* *"[..] I think it would be much better if at the end of the course those rewards could have been exchanged for a prize, not in terms of the overall score, but maybe to earn an invitation to participate in another MOOC organized by you."*

Table 3.20: Excerpts of evidence from participants belonging to the BADGE condition. Participants' answers could be classified into multiple categories.

Group REDEEM (48 participants)		
Perceptions	**N**	**Excerpts of Evidence**
The privilege of extending the due date of compulsory assignments as the most valued reward (*Glossary Master, Text Provider*)	17	*"The rewards I liked the most were the ones related with the deadline extension of some activities, especially when I did not have the time to complete them on the indicated date."* *"(I liked) Those who related with the deadline extension because I was doing the course while I was working, and having a little more time is always useful and appreciated."* *"The rewards that I liked the most were the Glossary Master! and the Text Provider, since apart from allowing us to contribute to the course with the terminological glossary and with numerous links to parallel texts, they extended the submission deadline of the tasks [..]"*
The privilege of being reviewed by the instructors of the course as the most valued reward (*Expert Reviewer*)	9	*"I found useful the reward which the teachers evaluated and commented my translation, because I was able to evaluate more or less my progress based on the teacher's evaluation [..]"* *"The rewards I liked the most were the ones related with the possibility of checking my learning and learn more, like the one that gave you the possibility of accessing additional readings or the one that the teachers assessed your work."* *"The rewards I liked the most were the one of receiving correction from the teachers and the one of accessing the video conference. The reason is that due to their experience I value their comments more."*
Lack of time to complete optional tasks as those involving rewards (without mentioning the extending due date privilege)	7	*"I couldn't complete the optional tasks associated to rewards because I did not have time."* *"I did not do the activities to earn rewards, because I did not have enough time."* *"I did not do any optional activity or try to earn a reward due to time issues."*
The privilege of getting extra attempts in the quizzes as the least valued reward (*Welcome, Translator Master*)	6	*"[..] I did not like the ones that offer extra attempts in the questionnaires since I did not know if the grade was going to change or not."* *"[..] On the other hand, I think that giving additional attempts to answer the questionnaires is excessive; three attempts are enough."* *"[..] Regarding the ones I liked the least, these were the ones that offered extra attempts in the questionnaires because, in general, I only made one attempt."*
No interest on earning rewards	5	*"I was interested neither in the rewards nor in the privileges"* *"They did not motivate me because my goal was to learn from the content videos and from the provided the information. Due to the vast material I did not have time to perform the activities connected with the rewards."* *"[..] I got the rewards with the work done, I did not do tasks especially to get rewards. From the beginning I knew that I would not be able to complete the optional tasks, my goal was to complete the obligatory tasks and read the obligatory readings."*

Table 3.21: Excerpts of evidence from participants belonging to the REDEEM condition. Participants' answers could be classified into multiple categories.

privileges than the digital recognition of the reward. In this condition, *extending the due date* of compulsory assignments and *being reviewed by the course instructor* were identified as the most valued privileges by students (17 and 9 students respectively, out of 48). That is, *Glossary Master*, *Text Provider* and *Reviewer Master* were the favorite rewards reported by students from the REDEEM condition. On the contrary, the rewards associated with extra attempts in the quizzes were reported by some students as less engaging due to the low difficulty of quizzes. Finally, 5 participants reported indifference toward course rewards and 7 students indicated the lack of time to attain them.

3.4.6 Limitations

This study presented some limitations. Similarly to the first version of the course (TraduMOOCv1), the MOOC target to concrete Spanish-speaking population interested on translation in the business and economic fields. It would be interesting to analyze to what extent this MOOC and gamification design (*e.g.*, number of implemented rewards, type of activities associated with rewards, rewards only visible to students themselves, rewards associated with optional tasks) affected the results of this study, and if the adaptation of this design to other topics and contexts would have similar effects [111, 253]. Further evaluations involving reward-based strategies in other MOOCs with different topics, features, language and target population are needed to generalize the results of this study. In future versions of the same course, we plan to analyze the extent to which the aforementioned gamification parameters would change the effects on retention and engagement reported in this study.

Furthermore, although a Chi-square homogeneity test was performed to control demographic student variables (*e.g.*, gender, age) among the three groups of the study, all students were equally treated without considering their initial intentions to finish the course. Future work could involve the initial classification of the different learner profiles enrolling in MOOCs [150, 2]. Therefore, we could understand whether, for example, students that planned to only check the content, participated in certain activities due to gamification strategies.

3.4.7 Discussion

This third empirical study provided additional evidence about the effects of reward-based strategies in the engagement of MOOC students. Additionally, this case allowed us to compare the effects of two experimental conditions implementing two different types of rewards with a control group within the same course, which was scarcely explored in MOOCs so far. The gamification design was co-created with the main instructor of the course with the purpose of promoting task participation and enhancing learners' engagement.

The results gathered in this study helped answer *RQ2. To what extent reward-based strategies foster student retention, engagement and reward-derived engagement in MOOCs?* Reward-based strategies (experimental groups): [H_O1] did not lead to a higher student retention; [H_O2] did not significantly increase student behavioral engagement (measured in terms of number of pages visited, tasks submitted, forum posts and activity time); and,

[H_O4] did not promote participants to complete the gamified activities earlier. These results might diverge from other empirical gamification studies performed in online and blended learning contexts (*e.g.*, [8, 130]). However, these same results converge with some other studies carried out in massive environments where gamification did not show higher student retention and engagement (*e.g.*, [234, 156]). These results remark the importance of the context (*e.g.*, MOOCs) and the individuals (*e.g.*, heterogeneity of learners) in the gamification design [111, 253].

On the other hand, results also showed that: reward-based strategies [H_O3] encouraged participants to satisfy the reward conditions (*e.g.*, participate in optional activities, get high score in quizzes) as compared with the control group; and [H_O5] had an impact in the time when rewards were claimed (*i.e.*, redeemable rewards were claimed sooner than badges), which could be interpreted as an impact on the students' intentions to earn such rewards. These results support one of the purposes for which the gamification was implemented in the course: promoting task participation. This potential effect could be used by MOOC practitioners to enhance the attainment of some specific pedagogical goals. Nevertheless, the inclusion of course privileges into MOOCs showed new variables in the alignment of gamification designs with the expected learning goals (*e.g.*, which privileges should be implemented). Therefore, although the desired spill-over effect (*i.e.*, higher retention and general behavioral engagement generated by reward-based strategies) was not observed, the benefit of focusing students' attention on specific activities and promoting their participation can be positively used by practitioners. Thus, guides and tools supporting practitioners in the orchestration of reward-based strategies (especially redeemable rewards) could be useful to attain their expected gamification and pedagogical goals.

In summary, results suggest that learners unlikely to complete the MOOC due to external reasons (*e.g.*, lack of time, lack of previous knowledge, or lack of interest on the course contents), will neither be engaged with the reward strategies (regardless of the reward type used). However, results also suggest that reward strategies potentially encourage learners who are already motivated to complete the course (*e.g.*, interest on course topic and contents) to perform optional tasks that would otherwise not be fulfilled. This effect can be used by instructors to promote specific learning goals, such as the learners' completion of optional tasks beneficial for their learning (providing a good alignment between the gamification design and pedagogical goals).

3.5 Conclusions

Within the context of this dissertation, and as reported in this chapter, we have performed three empirical studies analyzing the students' behaviors and perceptions in MOOCs incorporating reward-based strategies. The first two studies focused on understanding whether there are significant correlations between earning rewards and variables measuring student engagement (*e.g.*, number of visited pages, tasks submitted). The third study dealt with understanding the actual effects on task participation, behavioral engagement and student retention caused by two different types of reward-based strategies (*i.e.*, achievement badges and course privileges). These studies were proposed to answer the following research sub-questions.

RQ1. Which are the students' behaviors and perceptions toward earning rewards in MOOCs incorporating reward-based strategies?

RQ2. To what extent reward-based strategies foster student retention, engagement and reward-derived engagement in MOOCs?

Regarding RQ1, student reward-derived engagement drastically decreased throughout the courses, as usually happens with student behavioral engagement in MOOC environments [3]. That is, at the beginning of the course, students seem to be curious and interested to earn rewards but while the course is advancing, they lose such curiosity and interest. This behavior was observed in the three studies, thus sustaining the importance of 'successful' gamification designs involving numerous engaging rewards during the first weeks of the course.

Attending to the reward-derived engagement of participants in the first study, we identified two clusters of students: high and low reward-derived engagement. This classification was also observed in the other two studies in which there were students attempting to earn all the rewards and some other students that avoided the gamification of the course. These two clusters of students were also observed in the student comments provided in the final questionnaire where some students mentioned their weekly motivation to earn them, while some others lacked intentionally avoid them, among the main reasons, the only interest on learning and the lack of time.

Moreover, in the first study, we observed that those students completing the final questionnaire and reporting to feel extra motivation by course rewards, experienced a significant higher behavioral engagement than those students who were not motivated. That is, students motivated by the possibility of earning badges, actually earned more badges, claimed them sooner, visited more course pages, etc.

Furthermore, results showed a high correlation between the variables measuring student behavioral engagement and the variables measuring reward-derived engagement (RQ1). However, since correlation does not involve causality, the question whether students are more engaged due to the possibility of earning rewards, or students earn more rewards because they are already engaged due to the course contents and activities, emerged. In our last study, results showed that badge and redeemable rewards did not increase significantly student retention and behavioral engagement (RQ2). Nevertheless, reward-based strategies were able to significantly promote student participation in optional gamified activities as compared with a control group without rewards. Therefore, MOOC practitioners could benefit from reward-based strategies to engage participants within the course and with specific learning activities whose participation can be beneficial for them.

Additionally, perceptions toward rewards were generally positive (RQ1). In the three studies, most students reported that the possibility of earning rewards improved their perceived behavioral engagement (*e.g.*, number of pageviews, submitted tasks, activity time). Additionally, students reported that the main reasons for collecting badges (the first two studies) were the feeling of progression and the motivation to collect them. While, on the other hand, competition did not represent a strong reason to achieve badges despite a public leaderboard was configured in both cases.

The literature review reported in Chapter 2 revealed a lack of studies describing potential design guidelines (*i.e.*, recommendations towards the design of gamification strategies

in MOOCs regarding student engagement) based on empirical data from real gamified MOOCs. Recommendations for the design of reward-based strategies could be beneficial for MOOC researchers and practitioners to 'successfully' achieve the gamification purposes that want to be promoted on MOOC learners, and to connect them with the learning design. Although the provision of gamification design guidelines is not conceived as a goal of this dissertation, a set of guidelines for 'successful' gamification design have been derived from these studies:

- The first weeks of the course seem crucial to engage participants with course rewards. Therefore, practitioners should locate numerous rewards targeting different profiles (*e.g.*, quiz achievers, socializers) during these first weeks to engage students with the course content.

- Redeemable Rewards showed a similar impact on student behavioral engagement than badges. However, student reward-derived engagement seems to be higher with this type of rewards as compared with badges. That is, students participated more in gamified activities during the first weeks of the course with redeemable rewards, and students claimed and earned them early than the badges.

- Some rewards were preferred than others due to the associated condition and/or privilege. In the first study, badges associated to getting high score in quizzes and to performing extra revisions in peer reviews showed a higher ratio of students earning the rewards than to other types of activities. This higher interest on these type of badges was also observed in the final questionnaire where more than 50% of respondents that badges encouraged them to participate in quizzes and peer review activities. In the second study, it was observed that some configurations in gamified quizzes had an impact on student participation and accomplishment. The number of attempts provided was associated to the number of students satisfying the 100% score condition. Therefore, the number of attempts provided in gamified quizzes should be configured slowly decreasing to keep students engaged in the *flow* zone throughout the course. Additionally, collaborative quizzes experienced a very low participation as compared with the individual gamified quizzes. In the third study, the rewards associated peer reviews (as observed in the first study) and video-content conditions were the top earned. Attending to the associated privilege of redeemable rewards, 'extending the due date of compulsory activities' and 'receive feedback from course instructors' took the most attention of students by far.

In summary, this set of studies adds further evidence to the scarcity of research about the effects on MOOC students caused by gamification strategies (in this case, badges and redeemable reward strategies). The results obtained from the reported studies support the use of reward-based strategies to promote some specific student behaviors (*e.g.*, participation in optional activities beneficial for student learning) and to engage a certain profile of learners. However, many MOOC practitioners do not know how to put into practice these strategies potentially beneficial for the learners. Therefore, these studies support the need of conceptual and technological tools helping MOOC practitioners to orchestrate

reward-based strategies and to adopt them into their practice, a limitation also observed in the reported systematic literature review.

Chapter 4

GamiTool: A Gamification System for MOOC Environments

Summary: The results reported in the previous chapter provided **additional evidence about the potential benefits of reward-based strategies** in MOOC environments. MOOC practitioners can use these strategies **to promote student participation and to eventually increase the reward-derived engagement** of many course participants. However, the design, instantiation and management of these strategies **imply an additional time and workload** that may hinder their use and adoption by practitioners. With the purpose of understanding the current support provided by existing gamification systems, this chapter describes **a feature analysis** of gamification systems supporting the orchestration of reward-based strategies in MOOCs. Results showed two important limitations: **(a) a lack of design expressiveness** hindering the design and implementation of reward strategies in MOOC platform native tools; and **(b) a lack of technological support** addressing the affordable orchestration of these strategies. To help overcome such limitations, this chapter proposes the development of a system (*i.e.*, GamiTool) implementing: **a gamification data model** (GamiTool-DM), supporting the design of reward-based strategies in MOOC platforms native tools; and, **a system architecture** (GamiTool-ARCH), supporting the automatic deployment and management of reward-based strategies in multiple MOOC platforms and external tools; The **implications of the proposed contribution** in the design, instantiation and management of reward-based strategies in MOOCs are discussed throughout this chapter.

4.1 Introduction

The results reported in the previous chapter pointed out a positive impact of reward-based strategies on student participation and reward-derived engagement in MOOCs. Accordingly, these strategies could be used to enhance students' engagement and to promote the completion of tasks beneficial for their learning. However, the orchestration of reward-based strategies implies a set of tasks for practitioners in addition to the work already employed to orchestrate a MOOC (see Section 2.3.5).

Among other tasks, the use of reward-based strategies potentially involves: *(a)* the

reflection on the gamification design attending to the course pedagogical goals, to the behaviors that want to be promoted with gamification and to the alignment of such purposes with the pedagogical contents [190]; *(b)* the instantiation of the gamification design into the MOOC platforms (*e.g.*, shape the gamification design according to platform capabilities, configure the gamification features in the MOOC platform) [10]; and, *(c)* the management of reward-based strategies during course run-time (*e.g.*, monitor the effect of rewards on student behavior, check the satisfaction of conditions) [118].

Given this situation, the orchestration of reward-based strategies can become complex, time-consuming and cognitively-costly for MOOC practitioners, hindering their use and adoption [69]. This situation can be aggravated when practitioners lack previous experience with either MOOC environments or with gamified learning situations [7]. Therefore, gamification systems and MOOC platforms are desired to provide practitioners with tools supporting the development of the aforementioned tasks.

According to the associated gamification tasks presented before, gamification systems should enable the digital representation of MOOC learning designs incorporating reward-based strategies, thus providing a computer-interpretable model for automation purposes in such massive learning contexts. This model should feature a high *design expressiveness*, allowing the representation of as many as possible reward-related decisions without constraining the gamification purposes and course pedagogical goals. Limitations in the design expressiveness might hinder the use of reward-based strategies and their alignment with the pedagogical goals of the course, thus precluding their benefits and increasing the possibility of producing negative counter effects (*e.g.*, off-task behavior) [9, 40, 7]. For instance, let us imagine a practitioner that wants to promote collaborative learning in groups with gamification elements. However, if the gamification data model does not support group conditions, practitioners will be forced to change or remove such purpose from the gamification design.

Apart from a high design expressiveness, gamification systems should support the orchestration, by practitioners, of reward-based strategies in MOOCs in an affordable way [69]. This eventual affordability might reduce one potential barrier for the adoption of gamification. Also, the automation of gamification demanding tasks, specially at high MOOC scales, such as the reward-issuing procedure can help save time and effort to MOOC practitioners. Additionally, gamification systems operating over multiple MOOC platforms would help to reach a higher practitioner population due to the existence of multiple non-predominant MOOC platforms [255, 257]. All these features contributing to reduce the time cost and cognitive workload of using reward-based strategies have been categorized in this chapter under the concept of *practitioners' affordability and adoption* features.

Nevertheless, the design of gamification systems should not only focus on practitioners, but also on students. Systems presenting a high design expressiveness and affordability could fail in engaging students within gamification strategies, and therefore, fail in obtaining the expected gamification benefits. The visual representation, the integration between the gamification system and the MOOC platform or the low usability can be factors affecting to positive learners' gamification experiences [8]. Throughout this chapter, all these features related to the student experience with system have been categorized under the topic of *positive learners' experience*.

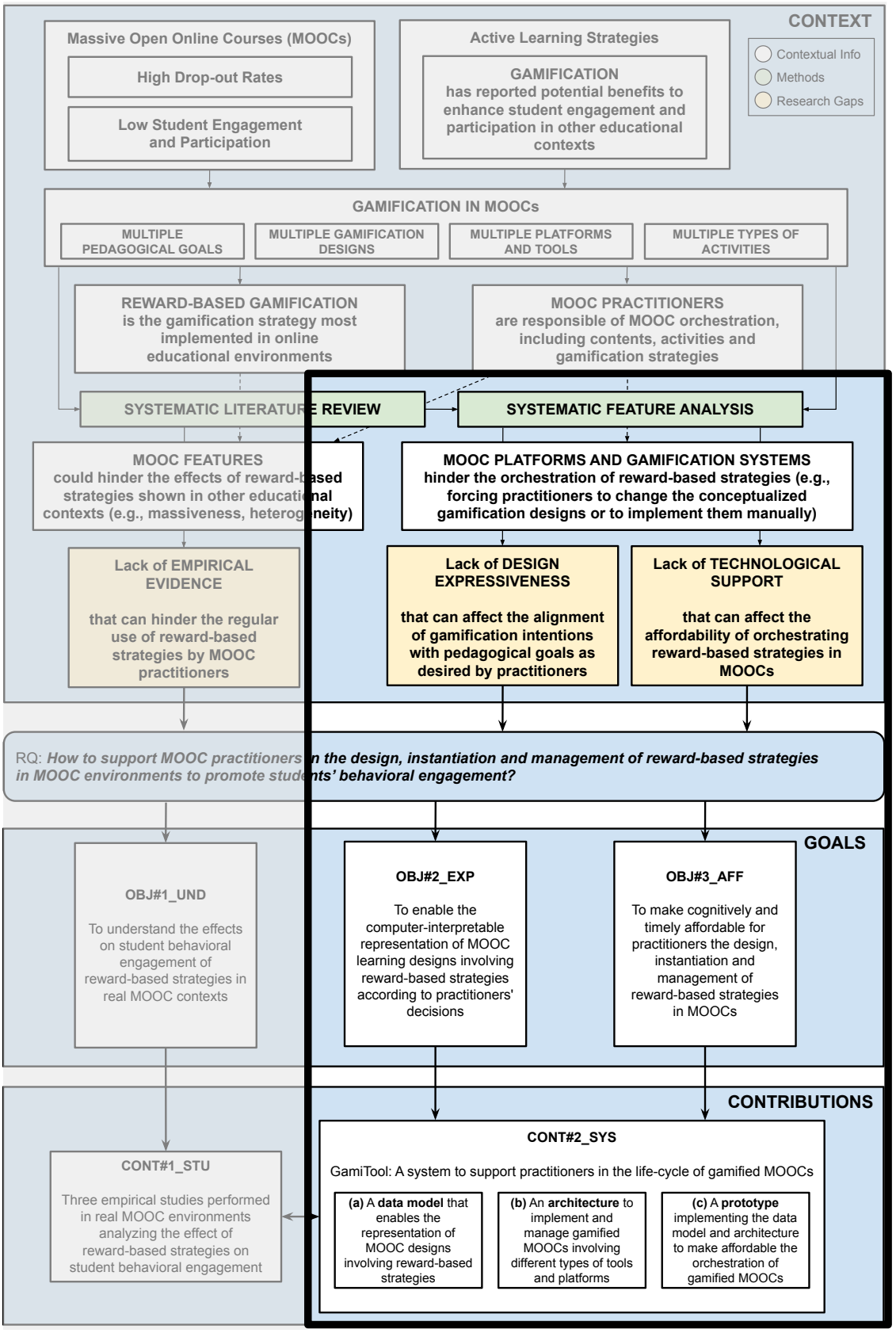


Figure 4.1: Overview of the research gaps, objectives and contributions addressed in Chapter 4.

This chapter reports a systematic feature analysis to understand the extent to which current gamification tools and MOOC platforms support the three identified topics (*i.e.*, design expressiveness, practitioners' affordability and adoption, positive learners' experiences). The systematic feature analysis helped identify the limitations of current gamification systems that could hinder the affordable use and adoption of reward-based gamfication strategies in MOOC environments. In order to help overcome such identified limitations, and as part of this dissertation's objectives, this chapter also describes the second contribution of this dissertation: GamiTool, a gamification system to support practitioners orchestrate MOOCs involving reward-based strategies.

This system is formed by two main components: GamiTool-DM, a data model that enables the representation of MOOC designs incorporating reward-based strategies (Section 4.3.1); and GamiTool-ARCH, a system architecture to automatically deploy and manage gamified MOOCs (Section 4.3.2). A GamiTool prototype implementing both GamiTool-DM and GamiTool-ARCH was developed as reported in Section 4.3.3. Finally, the limitations, conclusions and relevance of such proposals are outlined in Section. 4.4. Figure 4.1 depicts the connections between the aforementioned research problems, the general research questions of this dissertation, the objectives and the contributions formulated in this chapter.

4.2 Feature Analysis

The systematic literature review presented in Chapter 2 showed the limited number of systems supporting the lifecycle of gamification in MOOC contexts. This fact led us to carry out a *feature analysis* driven by the following research question: *To what extent current systems provide support to the orchestration of reward-based gamifications in MOOCs?* A feature analysis is a qualitative evaluation of the extent to which a set of tools provides the required features in a usable and effective manner [149]. The feature analysis should thus clarify the degree of support provided to MOOC practitioners regarding reward-based strategies in MOOC contexts.

4.2.1 Methodology

The feature analysis followed the DESMET methodology. DESMET is a systematic methodology proposed by Kitchenham [149] for evaluating and comparing software engineering tools. This methodology also provides guidelines and templates to perform feature analysis evaluations. DESMET has been previously used in other Technology-Enhanced Learning evaluations (*e.g.*, [192, 28]). More concretely, in this evaluation we follow the *screening mode* defined by Kitchenham [149] due to the existing limitations to obtain and test all collected software, and to involve gamification experts, as required by the other evaluation modes.

According to this mode, evaluations are based on the qualitative assessment of the literature describing the software tools by an individual (leading reviewer) who also determines (a) the features, (b) the systems, (c) the instruments and (d) the evaluation procedure [149]. The evaluation procedure will allow to consistently score the selected systems

according to the selected features. The individual score per feature and the final score per system will provide useful information to determine which are the systems and platforms providing more support to practitioners and which are their current constraints.

4.2.2 Analyzed Features

Given this dissertation's main goal and the context presented before, the features considered in this analysis are related to: *(i) design expressiveness:* the extent to which practitioners' decisions regarding reward-based strategies in MOOC learning designs can be digitally represented and computationally interpreted without being constrained; *(ii) practitioners' affordability and adoption:* the time and workload affordability of current systems to orchestrate reward-based strategies in MOOC environments; and *(iii) positive learners' experiences:* the degree to which the learners' are satisfied with their user experience.

The process followed to identify the important features from the three mentioned categories combined two approaches. First, a top-down approach in which empirical studies in real MOOC environments found in the systematic literature review were analyzed to understand the strategies and requirements currently used in these contexts. Second, a bottom-up approach regarding our experience in the provision of the first two exploratory cases of reward-based gamification in MOOCs presented in Chapter 3.

Design Expressiveness

The MOOC context (*e.g.*, topic, activities) and the characteristics of its cohort of participants are two important variables in the gamification design that potentially impact the effects of gamification on learners [111, 253]. Since there exists a myriad of MOOCs about hundreds of topics, each of them implementing different types of activities and resources, and targeting different learning populations (*e.g.*, software programmers, in-service teachers), systems supporting the design of reward-based strategies in MOOCs should permit a high flexibility in the design of gamified MOOCs [9, 40, 7]. This flexibility should allow practitioners achieve the gamification expected goals (*e.g.*, promote student positive interdependence); align the gamification purposes with the course pedagogical contents, tools and goals (*e.g.*, collaborative learning); and, avoid negative counter effects on students (*e.g.*, off-task behavior). The features analyzed in this category have been classified attending to the three main components of a reward-based design: [R] the rewards, [C] the conditions (completion logic), and [A] the associations that define which rewards are issued under which conditions:

DE1. **[R] Multiple types of rewards.** Researchers and practitioners use different types of rewards in MOOCs [144], among which, badges (*e.g.*, [8, 17]), badge suites (*e.g.*, [55, 240]) and points (*e.g.*, [286, 233]) are the most implemented. Other types of rewards also include votes (*e.g.*, [188]), medals (*e.g.*, [99]), and battery bars (*e.g.*, [143]). Gamification systems should support the use of different types of rewards, thus targeting the personal preferences of practitioners and aligning specific rewards with the goals of the gamification design (*e.g.*, while points promote students to

continue performing tasks in the course, badges stimulate the attainment of concrete achievements).

DE2. **[R] MOOC in-course privileges.** This kind of rewards have shown stronger potential over traditional rewards (*e.g.*, points, badges) to increase student motivation [234] and task participation [207] in MOOC environments. Gamification systems are expected to support course privileges connected with activities and tools typically used in MOOC environments (*e.g.*, deadline extensions in quizzes and assignments, unlock extra content and resources, extra attempts in quizzes).

DE3. **[C] Previous earned rewards.** According to the literature, researchers and practitioners sometimes provide rewards based on previous earned rewards [78, 267] (*e.g.*, a student level up when 1000 points are earned, a student receives a special badge when 3 badges are earned), thus fostering learners to keep participating within the gamified activities and progressing in the course. Consequently, this feature might be considered as a positive aspect of gamification systems.

DE4. **[C] MOOC frequent activities.** In most reward-based scenarios, rewards are issued when learners perform certain actions related with course resources [210] such as discussion forums (*e.g.*, [8, 233]), course assignments (*e.g.*, [55, 188]) or course quizzes (*e.g.*, [286, 240]). Gamification systems should automatically support the definition of conditions associated to learners' actions performed in frequent MOOC activities and tools (*i.e.*, discussion forums, quizzes, assignments, peer reviews, content pages and materials) [23, 128].

DE5. **[C] Fine-grain rules.** In most reward-based scenarios, rewards are issued when learners perform specific actions in the activities of the course. Sometimes these actions are configured ad-hoc or are predefined by systems (*e.g.*, submit an assignment, get full score in quizzes), thus limiting the application and effect of these strategies. According to Nicholson (2012) [199], practitioners should avoid generic games and gamifications not aligned with the learning contents and activities. Limitations in the definition of fine-grained rules (*e.g.*, submit an assignment before a specific date, get a higher percentage than 60% in the first attempt of a quiz) can lead to constraints and counter-effects in the gamification design. Gamification systems should thus support the design of fine-grained rules in frequent MOOC activities and tools.

DE6. **[C] Group conditions.** MOOCs provide an heterogeneous environment for knowledge sharing and collaborative learning among course participants [175]. Activities performed in groups can potentially increase collaborative learning among group peers. In this situation, practitioners could potentially use gamification conditions to be performed in groups, thus supporting individual accountability, positive interdependence and and interaction among group members [228]. Gamification systems are expected to allow practitioners to configure reward-based gamifications involving group conditions.

DE7. **[C] Peer approval.** Based on previous studies [55, 267], practitioners sometimes decide to leave the decision of whether a student satisfied the reward conditions or

not to other team members (*e.g.*, based on the work done for a collaborative task), thus promoting interaction and collaboration among course participants. Therefore, gamification systems should provide this capability to MOOC practitioners.

DE8. **[A] Configurable associations.** Although predefined associations (predefined reward/s issued under predefined condition/s) can help save time during the design of gamification strategies, they strongly hinder the configuration of personalized gamified designs. The limited configuration of conditions or associations different than the ones that are predefined can constrain the promotion of specific actions that practitioners believe beneficial for student learning and their alignment with course goals. Gamification systems are expected to provide freedom to select the type of conditions, and the quantity and type of rewards of all configured associations.

Practitioners' Affordability and Adoption

MOOC production and launch are generally time consuming and cognitively costly [73, 76]. Usually, practitioners are responsible for creating the MOOC learning design considering platform constraints, creating and sharing the contents (including video recordings, speeches, presentations, etc.); uploading and configuring the contents and activities to the platform; and managing course run-time issues and student questions. When using reward-based strategies, practitioners are additionally responsible of (a) gamifying the learning design according to the desired intentions they want to promote (*e.g.*, create the rules, select the conditions and rewards); (b) instantiating the gamification design in the platform (or hardcoding it [143]); and (c) managing the evolution of gamification during course runtime (*e.g.*, monitor the effect of rewards on student behavior).

All these gamification-related activities involve an extra work [69] added to the existing work employed by practitioners to produce and launch a MOOC. Therefore, it seems desirable that gamification systems support ICT non-expert practitioners, in the affordable orchestration of reward-based strategies. This subsection motivates and describes the features considered for the practitioners' affordability and adoption topic:

PA1. **MOOC-technology independent.** Currently, there is not a predominant MOOC platform [255, 257] and the selection of MOOC platform is often imposed by the institution. Aiming to reach the maximum number of practitioners and researchers, gamification systems should support as many MOOC platforms as possible.

PA2. **Integration with external tools.** Many MOOCs offer additional activities through tools external to the MOOC platform such as social networks (*e.g.*, Twitter, Facebook) [32] or collaborative tools (*e.g.*, Google Forms [207], GitHub [83, 84]). Gamification systems should support the design and management of gamification strategies performed within these external tools [77].

PA3. **Usable for practitioners.** In order to support practitioners' adoption of reward-based gamification in MOOCs, it is desirable that gamification tools are usable for them [69]. In this context, we refer to *usability* as the ability of target users to use the the thing (*i.e.*, gamification system) to carry out a task (*i.e.*, design, instantiate

and manage reward-based strategies) successfully [5]. Gamification systems are expected to be usable for ICT non-expert MOOC practitioners.

PA4. **Analytics support.** Instructors need to be aware of the gamification situation at course run-time and once it has finished (*e.g.*, how many rewards have been issued, who are the winners of the rewards) to understand how students are interacting with gamification strategies (*e.g.*, conditions too difficult), and to better address the potential raised problems [117, 116]. Therefore, gamification systems are desirable to provide gamification analytics for practitioners.

PA5. **Changes during enactment.** As observed in the gamification life-cycle, learning and gamification designs are susceptible to changes during course run-time. For instance, MOOC instructors ignore the number of students that will enroll before creating the gamification design of the course. This can lead to the design of too easy or too difficult conditions (*e.g.*, receive more than 100 likes in a post in a week with 90 active students) potentially disengaging students to earn rewards [57]. Therefore, it seems relevant that gamification systems support the edition of gamification designs during course run-time (*e.g.*, change the threshold of conditions, add more rewards, remove conditions).

PA6. **Automated issuing procedure.** The massive number of students enrolling in MOOCs may make the manual issuing of rewards by instructors non-affordable in terms of time and cognitive effort [77]. Gamification systems should automatically handle learners' requests of rewards, check the satisfaction of conditions, issue the corresponding reward/s and record them in the system database.

PA7. **Evidence of support with large cohorts.** The large number of enrolled students in MOOCs raises the possibility that gamification system databases handle many read and write operations in short periods of time. In this context, quick feedback to the learners is highly recommendable to keep them engaged [109]. Therefore, gamification systems are expected to implement robust and efficient database technologies able to support massive number of concurrent accesses.

PA8. **Automated deployment.** MOOC practitioners are responsible for designing and implementing the course contents and activities (*e.g.*, record videos, configure activities in the platform). When using gamification, practitioners are also responsible for designing and implementing the gamification strategies into the gamification system and/or MOOC platform where the course will be provided. The automatic configuration and integration of the gamification strategies in the MOOC platform (*i.e.*, deployment) can save time and effort to practitioners, thus fostering its adoption in their MOOC teaching practice.

Positive Learners' Experience

Positive learners' experiences with gamification strategies in learning environments are essential to avoid student disengagement with the course contents and with the gamification strategies. Otherwise, negative experiences would drastically diminish the motivational effects of gamification in such environments [77, 69]. This subsection motivates

and describes the identified system features affecting to learners' experience with gamification strategies in online learning environments:

LE1. **Gamification seamless integration.** When using third party gamification tools, learners sometimes have to re-login into a different system (embedded or non-embedded into the course). This can cause students to be reluctant to use gamification and disengage within the configured gamification and with the course. Gamification systems should provide seamless integration with the course without the need of re-logging.

LE2. **Claiming/Disable option.** According to Ruipérez-Valiente et al. (2017) [243], and to our empirical studies, different player profiles exist in online gamified environments. Learners included in some of these profiles usually consider that gamification strategies are non-interesting or non-motivating, conflicting with their actual learning motivations. In order to avoid unexpected effects in those students caused by gamification features, gamification systems should provide students with the possibility to choose whether they interact with the implemented gamification features or not, or to claim them or not.

LE3. **Usable for learners.** In order to promote students to use the gamification system and to avoid course disengagement, systems should be usable for learners. Therefore, gamification systems are expected to be usable from learners' perspective.

4.2.3 Systems

The systems to be included in the feature analysis have been selected from the systematic literature review presented in Section 2.5. Those publications categorized as *system proposals or prototypes* were screened by applying the following inclusion and exclusion criteria:

I1. Manuscripts describing platforms, editors or authoring tools that could be used by practitioners or administrators to orchestrate reward-based gamifications in MOOCs.

E1. Publications reporting platforms intended for other purposes different than teaching or learning in online environments (*e.g.*, e-commerce, tourism, software-development).

E2. Publications describing gamification systems without a developed prototype.

E3. Publications describing gamification systems for a specific learning topic (*e.g.*, programming).

Accordingly, 8 publications ranging from 2014 to 2018 and describing 5 different gamification systems intended for MOOC environments were identified: iMOOX [280], OpenHPI [268, 267], SBGF [40], MyMOOCSpace [227, 228, 226], and Gametize-based system [21].

Parameter	Decision	Reason
Databases	ACM Digital Library, IEEE Xplore, Digital Library, Science Direct, Scopus, and Springer Link.	We believe that these databases are the most relevant databases in the topic field. Additionally, these databases have been previously considered for literature reviews about gamification in education [61, 41, 71].
Search string	"gamif*" and ("editor" or "authoring tool") ("gamification" and ("editor" or "authoring tool") if restriction).	We aim to find publications describing authoring tools and editors for gamification including derivations of the gamification term such as 'gamified' or 'gamify'.
Search location	Title, abstract and keywords (metadata or abstract if restriction).	We expect that publications describing gamification systems for online learning environments will mention the search string in the title, abstract and/or keywords.
Time restrictions	No time restrictions (until April 2019).	We aim to consider all possible systems supporting the orchestration of gamification in online learning environments disregarding the time of publication.
Screening	By reading title and abstract first, then, if needed, the body text.	We suppose that publications describing gamification systems for online learning environments will summarize their main contributions and features in the title and abstract, providing enough information to apply the inclusion and exclusion criteria.
Inclusion criteria	[I1] Manuscripts describing platforms, editors or authoring tools that could be used by practitioners to orchestrate reward-based gamifications in online learning environments.	This analysis aims to investigate the features of current developed systems supporting reward-based strategies in online learning environments.
Exclusion criteria	[E1] Conference, workshop, book and chapter summaries or prefaces. [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 in online environments (*e.g.*, e-commerce, tourism, software-development). [E5] Publications describing gamification systems without a developed prototype. [E6] Publications describing gamification systems for a concrete learning topic (*e.g.*, programming).	The analysis of systems considered for other purposes different than gamifying online learning situations are out of the scope of this feature analysis.

Table 4.1: Summary of the literature review extension.

However, we realized that this search could be omitting some potential gamification systems developed in the educational domain but not intended for MOOC contexts. Although these systems were not developed targeting MOOCs, they could potentially satisfy many of the features previously identified as relevant for MOOCs. Therefore, we performed a second literature review not restricted to MOOC contexts, aiming to identify such gamification systems. The methodology followed to carry out this second literature review was similar to the previous one using the same digital databases and time restriction but changing the search string to *("editor" OR "authoring tool") AND ("gamif*")* and adapting the inclusion and exclusion criteria as presented in Table 4.1. As a result, we gathered 7 different publications ranging from 2014 to 2019 describing 3 additional gamification systems: OneUp [71, 68, 69, 70], INDIeAuthor [216, 217] and MEdit4CEP-Gam [39].

We also considered the inclusion of gamification plugins that can be integrated in online learning environments (including MOOCs) such as the ones considered for our empirical studies: Badgr[1] and Credly[2]. These platforms provide an usable and affordable gamification experience with a seamless integration with the MOOC platform. However, as self-experienced and as reported by Dicheva et al. (2018) [69], this kind of platform extensions provide a very limited design expressiveness, strongly hindering the conditions and rewards that can be implemented in learning management systems, including MOOC platforms. Consequently, we decided to exclude this kind of platform extensions from the feature analysis. Therefore, 8 systems described in 15 different publications were considered in this feature analysis.

4.2.4 Evaluation Instruments and Procedure

While some selected features can be classified with a yes/no answer (simple features), most of them can be measured in a degree of support scale (compound features), and therefore, a rating scale is needed [149]. The guidelines proposed by DESMET do not define a concrete rating scale to perform a feature analysis, which, in turn, has to be selected by the leading researcher (*i.e.*, the author of this dissertation) according to the features to be evaluated. In this feature analysis, a 3-rating scale was used to evaluate the systems due to practical issues. This rating scale refers to:

- "0" as "little or no support";
- "1" as "some support"; and,
- "2" as "strong or full support".

Additionally, those features mentioned in the manuscripts to be considered but not yet implemented in the developed prototypes were proposed to be marked with an asterisk (*). Reviewers were provided with a score sheet containing a description and rating criteria for every feature (*i.e.*, a rubric) and an empty questionnaire to be filled out with the given scores, the textual evidence and additional comments (if needed) for every reviewed system. The score sheet was created by the leading researcher and, after two iterations,

[1]Badgr: *https://info.badgr.io/*, last access: September, 2020.
[2]Credly: *https://info.credly.com/*, last access: September, 2020.

its content-related evidence of validity [94] was approved by three TEL research experts from GSIC-EMIC group. Further information about the rating criteria, the scale and the score sheet can be found in Appendix B.

Feature analysis are based on subjective judging methods and evaluations which are likely to be biased. In order to tackle this issue, the gathered manuscripts describing the systems were reviewed by at least 3 different researchers with previous experience in TEL and gamification. This reviewing approach together with the provision of the rubric aim to mitigate the risk of delivering incorrect results based on the qualitative assessment of the features [94].

The evaluation procedure started with the individual revision of the assigned systems and the score systems' features (see Table 4.2). The score table presented 127 (70.56%) consensus cases (all the reviewers provided the same score for the same feature and system); 50 (27.78%) soft non-consensus cases (most repeated value represents more than 50% of all values for a concrete feature and system); and 3 (1.67%) strong non-consensus cases (most repeated value represents equal or less than 50% of all values for a concrete feature and system). Gwet's AC2 agreement coefficients have been calculated to measure inter-rater reliability for these qualitative ordinal items among 2+ raters (note that scores 0-1-2 represent ordinal values and not numerical equidistant values) [106]. The R-Studio software and the *irrCAC* package[3] were used to calculate the coefficients. According to Landis and Koch benchmarking scale [107], the obtained Gwet's coefficients are deemed from 'fair' to 'perfect' level of agreement for all the features (except for DE5) and for all the systems, suggesting a considerable level of inter-rater reliability for this individual phase of scoring.

In order to understand and clarify the inconsistencies found, scores were analyzed by the leading researcher and presented in a discussion panel session with all the reviewers. Based on the textual evidence and the additional comments provided by reviewers, inconsistent results were solved (see Table 4.3). Non-consensus features still presenting conflicts or lack of evidence were provided with the highest score given by reviewers (*e.g.*, a feature with 1,1,0 scores was provided with a 1 score). Furthermore, reviewers agreed on adding a new feature [PA8] based on the additional comments provided in the score sheet due to the existence of an unclear feature combining two characteristics.

Finally, authors of the three top-rated systems were contacted via email to confirm the features of such systems and to avoid misinterpretations. The emails contained a set of statements describing the features of the systems which had to be confirmed or edited by their authors, thus avoiding authors rating their own systems. In case of discrepancies between reviewers' scores and authors' statements, authors' arguments were prioritized and converted to scores according to the given rubric. The information provided by the three top-rated system authors (*i.e.*, OneUp, INDIeAuthor, MEditCEP-Gam) led to 5 changes (see Table 4.3) resulting in the final outcome of the feature analysis (see Table 4.4 and Table 4.5).

[3]Computing Chance-Corrected Agreement Coefficients (CAC): *https://cran.r-project.org/web/packages/irrCAC/irrCAC.pdf*, last access: September, 2020.

System	DE1	DE2	DE3	DE4	DE5	DE6	DE7	DE8	PA1	PA2	PA3	PA4	PA5	PA6	PA7	LE1	LE2	LE3	*AC2*
OpenHPI	2222	0000	2021	2222	0202	0000	2022	0000	0001	0000	0000	0000	0000	2222	2222	2222	0001	0000	.827
iMOOX	000	000	000	001	010	000	000	200	212	001	000	000	000	222	111	222	122	001	.776
Gametize	212	001	000	212	011	000	222	212	000	000	000	000	000	222	000	222	002	000	.795
MyMOOC	221	110	000	000	110	222	000	000	222	000	000	000	000	220	100	200	000	221	.729
SBGF	221	121	200	000	222	000	000	222	222	001	000	000	020	222	010	222	000	000	.735
OneUp	222	122	222	002	222	000	000	222	000	000	222	222	000	222	100	022	002	222	.731
INDIeAuth.	122	111	222	222	121	020	000	120	222	020	212	222	000	222	022	222	000	000	.589
MEdit4CEP	222	000	020	222	222	000	020	222	222	002	122	222	000	222	112	002	000	000	.643
AC2	.805	.747	.629	.699	.554	.887	.771	.617	.901	.693	.891	1	.910	.885	.493	.637	.660	.904	
Std. error	.089	.126	.211	.191	.208	.120	.175	.234	.076	.174	.095	0	.097	.123	.214	.237	.206	.081	
Strength	Sub.	Mod.	Fair	Fair	Fair	Sub.	Mod.	Fair	Sub.	Mod.	Sub.	Perf.	Sub.	Sub.	Slig.	Fair	Fair	Sub.	

Table 4.2: Scores provided by reviewers (green: consensus, yellow: soft non-consensus, red: strong non-consensus). Asterisks (*) have been excluded for better comprehension. *AC2* refers to Gwet's AC2 agreement coefficient.

System	DE1	DE2	DE3	DE4	DE5	DE6	DE7	DE8	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	LE1	LE2	LE3
OpenHPI	2	0	2*	2	0	0	2	0	1	0	0	0	0	2	2	2	2	0	0
iMOOX	0	0	0	0	0	0	0	0	2*	0	0	0	0	2	1	0	2	1	1
Gametize	2*	1	0	2	0	0	2	2	0	0	0	0	0	2	0	0	2	0	0
MyMOOC	2	1	0	0	1	2	0	0	2*	0	0	0	0	2	1	0	1	0	2
SBGF	2	1	0	0	2	0	0	2	2	0	0	0	2	2	1	0	2	0	0
OneUp	2	2	2	0	2	0	0	2	0	0	2	2	0	2	1	0	0	2	2
INDIeAuth.	2	1	2	2	2	0	0	1	2	0	1*	2	0	2	2	0	2	0	0
MEdit4CEP	2	0	0	2	2	0	2	2	2	0	2	2	0	2	1	0	0	0	0

Table 4.3: Scores agreed by reviewers after discussion panel (yellow: scores corrected by systems' authors).

System	DE1	DE2	DE3	DE4	DE5	DE6	DE7	DE8	∑DE
OpenHPI	2	0	2*	2	0	0	2	0	**8**
iMOOX	0	0	0	0	0	0	0	0	**0**
Gametize	2*	1	0	2	0	0	2	2	**9**
MyMOOC	2	1	0	0	1	2	0	0	**6**
SBGF	2	1	0	0	2	0	0	2	**7**
OneUp	2	2	2	0	2	0	0	2	**10**
INDIeAuth.	2	1	2	2	2	0	0	2	**11**
MEdit4CEP	2	0	0	2	2	0	2	2	**10**
Median	2	1	0	1	1.5	0	0	2	**8.5**

Table 4.4: Final scores for design expressiveness features.

System	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	∑PA	LE1	LE2	LE3	∑LE	Score
OpenHPI	1	0	0	0	0	2	2	2	**7**	2	0	0	**2**	**17**
iMOOX	2*	0	0	0	0	2	1	0	**5**	2	1	1	**4**	**9**
Gametize	0	0	0	0	0	2	0	0	**2**	2	0	0	**2**	**13**
MyMOOC	2*	0	0	0	0	2	1	0	**5**	1	0	2	**3**	**14**
SBGF	2	0	0	0	2	2	1	0	**7**	2	0	0	**2**	**16**
OneUp	0	0	2	2	2	2	1	2	**11**	0	2	2	**4**	**25**
INDIeAuth.	2	0	1*	2	2	2	2	0	**11**	2	0	0	**2**	**24**
MEdit4CEP	2	0	2	2	0	2	1	0	**9**	2	0	0	**2**	**21**
Median	2*	0	0	0	0	2	1	0	**7**	2	0	0	**2**	**16.5**

Table 4.5: Final scores for practitioners' affordability and adoption, and learners' experience features.

4.2.5 Results and Discussion

Design expressiveness

According to final results (see Table 4.4), gamification systems generally allow the design and deployment of multiple reward types in MOOC gamification designs [DE1] (mode value: 2). While some systems allow the implementation of a single in-course privilege (usually *unlock extra content*), only OneUp supports the implementation of privileges involving tools such assignments (*e.g.* deadline extensions), quizzes (*e.g.*, extra attempts) and peer reviews (*e.g.*, less compulsory revisions) [DE2]. Besides, most systems allow configurable associations between such rewards and the configured conditions [DE8] (mode value: 2).

However, gamification systems present certain limitations in the design and implementation of conditions. Only two systems (OneUp and INDIeAuthor) allow the configuration of conditions based on previous earned rewards [DE3]. Only two systems (INDIeAuthor and MEdit4CEP-Gam) allow the configuration of conditions based on student actions performed in MOOC frequent activities with fine-grain rules [DE4][DE5]. Additionally, only one system (MyMOOCSpace) addresses the design and implementation of collaborative gamified activities [DE6], although three (OpenHPI, Gametize-based and MEdit4CEP-Gam) of them support peer recognition for rewarding [DE7].

In summary, results show that gamification systems with higher design expressiveness are INDIeAuthor (11 out of 16), OneUp (10) and MEditCEP-Gam (10), the systems found in the additional search and which were not intentionally developed for MOOC environments.

Practitioners' affordability and adoption

Attending to final results (Table 4.5), all systems provide an automatic issuing procedure including the ones not originally intended for massive environments [PA6] (mode value: 2). Additionally, most systems have been tested in either simulated or real environments, although only two of them (OpenHPI and INDIeAuthor) in massive real contexts, thus testing their robustness and efficiency for large cohorts [PA7] (mode value: 1). Many systems have been designed to be technology-independent, being implementable within existing LMS and MOOC platforms [PA1] (mode value: 2). However, systems implementing a technology-independent architecture (SBGF, INDIeAuthor and MEdit4CEP-Gam) are self-contained systems without being able to gamify the native tools of MOOC platforms and LMSs such as Open Edx, Canvas Network or Moodle. These systems provide their own gamified tools that are inserted into the learning environments, forcing practitioners and students to learn how to use them.

Conversely, only three systems (OneUp, INDIeAuthor and MEdit4CEP-Gam) reported analytics support [PA4] (mode value: 0), out of which OneUp and INDIeAuthor permit changes during course enactment [PA5] (mode value: 0). Furthermore, only two systems (OneUp and OpenHPI) allow the automated deployment of the gamified learning designs [PA8] (mode value: 0). It seems significant that none of the analyzed systems support the gamification of student actions performed in third-party tools [PA2]. Finally, only three systems (OneUp, MEdit4CEP-Gam and INDIeAuthor) have evaluated the usability

of the tool regarding the design and deployment for real practitioners [PA3].

In brief, results show that gamification systems presenting a higher practitioners' affordability are the same systems that presented higher design expressiveness: INDIeAuthor (11 out of 16), OneUp (11) and MEditCEP-Gam (9).

Learners' experience

As presented in Table 4.5, most gamification systems can provide seamless integration with learning management systems or MOOC platforms [LE1] (mode value: 2). However, only two systems (OneUp and MyMOOCSpace) have assessed their usability level from the learners' perspective with positive results [LE3]. In this context, iMOOX presented a voluntary feedback provision about students' experiences with the platform which provided useful hints associated to system usability. Additionally, OneUp and iMOOX are the only systems allowing students to enable and disable the gamification features according to their preferences [LE2].

In summary, results show that gamification systems presenting a better learner experience are OneUp (4 out of 6), iMOOX (4) and MyMOOCSpace (3).

Top-rated systems

Attending to the final scores of this feature analysis (see Table 4.5), the top-rated systems are OneUp (25), INDIeAuthor (24) and MEdit4CEP-Gam (21). It is remarkable that these systems were not intentionally developed for MOOCs and were found in the additional literature review. This fact highlights the lack of systems and studies addressing gamification in MOOCs from practitioners' perspective already observed by An et al. (2020) [7]. A more detailed description of each top-rated system is presented below.

OneUp (25) [69, 71, 70, 68] is a highly configurable gamification tool aiming to facilitate practitioners the gamification of educational courses focused on skill development. OneUp provides practitioners with a graphical interface that allows the configuration of multiple types of rewards (including in-course privileges) associated to *challenges* (*i.e.*, tests or quizzes) [DE1][DE2]. OneUp supports the free configuration of gamification associations [DE8] in which conditions can be linked to previous earned rewards [DE3] and to students' actions performed within *challenges* [DE4]. The system is a gamification platform itself without permitting the gamification of activities performed in mainstreamed MOOC platforms, LMSs and external tools [PA1][PA2]. OneUp support practitioners with automatic deployment [PA8] and rewarding [PA6] mechanisms, gamification analytics [PA4] and allows changes during course run-time [PA5]. Furthermore, it has been tested in real small-scale environments [PA7] and its usability has been evaluated from both instructor [PA3] and student [LE3] perspectives with positive results (see Fig. 4.2). Additionally, OneUp supports learners' experience by allowing students to enable or disable the gamification components [LE2]. However, in case of using this system within a MOOC, students would need to externally access OneUp and log-in with the platform credentials [LE1]. In brief, OneUp includes many features supporting practitioners' affordability and adoption of reward-based strategies in online courses.

Nevertheless, OneUp was designed as a platform for practicing and self-assessment exercise problems targeting particular skills and was not originally designed as a content

platform. Consequently, OneUp constrains the configuration of conditions associated to MOOC frequent activities different than quizzes such as video-watching, peer review, assignment submission, posting, etc. Furthermore, the design expressiveness of OneUp hinders the configuration of conditions associated to collaborative group tasks and peer assessment.

INDIeAuthor (24) [216, 217] is a technology-independent system that can be integrated with existing LMSs and MOOC platforms through LTI [PA1] and which provide tools (*e.g.*, gamification analytics, changes during enactment) to support practitioners during course run-time [PA4][PA5]. This system allows the configuration of multiple types of rewards (*i.e.*, points, badges, missions) [DE1] in multiple types of activities [DE4] with fine-grain rules [DE5], presenting a high design expressiveness (except for group and peer approval activities) [DE6][DE7].

Nevertheless, the system presents three significant limitations regarding practitioners' affordability and learners' experience features. First, although the gamified activities are seamlessly integrated in the learning platforms through LTI [LE1], the resources that can be gamified are part of the gamification system itself, which have to be developed beforehand. Therefore, the native tools of MOOC platforms cannot be gamified, thus forcing practitioners and students to learn new tools. Second, the system lacks graphical user interfaces supporting the design and implementation of reward-based strategies for ICT non-expert MOOC practitioners (see Fig. 4.3). Therefore, although their usability evaluation showed positive results for programming-expert practitioners [PA3], such positive results could be compromised for ICT non-expert practitioners. Last, the usability of the system has not been evaluated by learners [LE3], who are forced to participate even if they dislike gamification strategies [LE2].

MEdit4CEP-Gam (21) [39] is a highly configurable system implementing multiple types of rewards and condition forms. The system supports practitioners in the design of reward-based strategies for multiple LMSs and MOOC platforms (see Fig. 4.4). However, the system presents three main restrictions in its design expressiveness. The system is not able to represent course privileges, conditions based on previous earned rewards and conditions based on group actions. Besides, the system also presents two constraints already described in the previous system: the native tools of MOOC platforms cannot be gamified, thus forcing practitioners and learners to use and learn new tools; and, the system forces students to participate within the gamification even if they dislike their features.

Discussion

In summary, results from the feature analysis pointed out the limited number of systems supporting the use of reward-based gamifications in MOOCs: 5 systems/platforms intentionally developed for MOOCs and 3 extra systems that were developed for small-scale context but which could be used in MOOCs. According to the results (see Table 4.4 and Table 4.5), most systems support some design expressiveness features (median value: 8.5/16) but lack features supporting practitioners' affordability (median value: 7/16) and positive learners' experiences (median value: 2/6). Results also showed that top-rated systems were the three systems which were originally developed for other purposes different

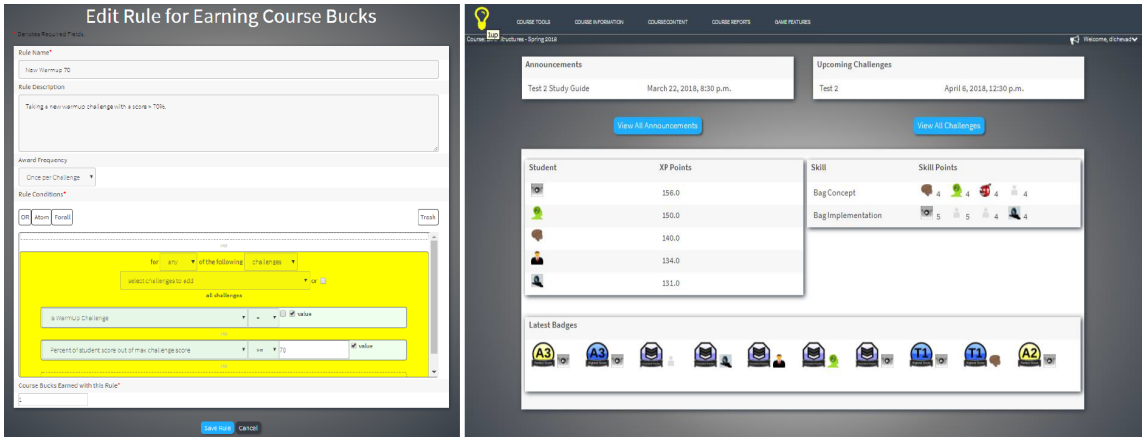


Figure 4.2: Oneup interface examples: (left) gamification designer, (right) student interface [69].

```
1  Gamification{
2   import upctforma.template1.*, upctforma.unit1.*,
3          upctformaevalua.evalua1.*;
4   badges{
5    Badge Badge1 {
6     description 'Badge obtained by final unit 1'
7     url 'evaluation1.jpg'
8   } }
9   WidgetPoint{
10   widget RectangleDragAndDrop
11    Point{ type completed points 100 attempt 1 },
12    Point{ type completed points 80 attempt 2 },
13          Point{ type completed points 50}
14  }
15  UnitPoint{
16    evaluationunit 'Evaluation1'
17    URL 'https://server_url/evaluation1/index.php'
18    image './images/evaluation1.png'
19    BadgeUnit{ type completed Badge1 Evaluation1 }
20    Point{ type scores points 10
21      InitialScore 40.00 FinalScore 49.99 },
22    Point{ type scores points 60
23      InitialScore 50.00 FinalScore 79.99 },
24    Point{ type scores points 100
25      InitialScore 80.00 FinalScore 100.00 }
26    missions{
27     Mission{
28      InitialPoint 80 FinalPoint 160
29      extraunit 'Extra Unit 1'}
30  } } }
```

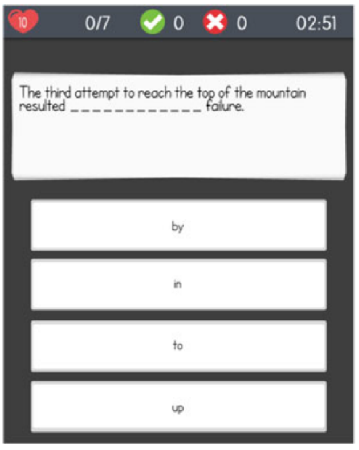


Figure 4.3: Example of gamification design script for INDIeAuthor (left) [217] and student interface (right) [216].

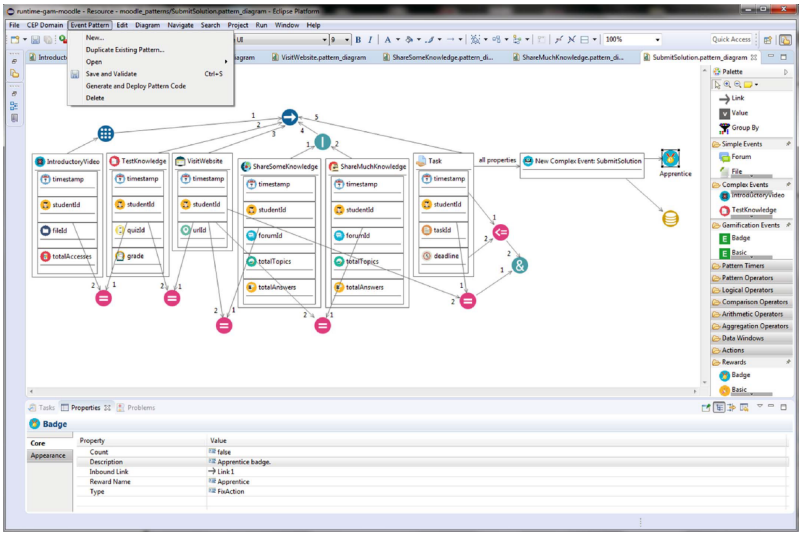


Figure 4.4: MEdit4CEPGam designer interface [39].

than MOOCs. This might be explained due to the recent use of gamification strategies in MOOCs, as compared with their more mature use in other learning settings such as blended and online learning.

The fact that these systems were not explicitly designed for MOOC environments, poses important limitations hindering their use and adoption in such massive environments. First, OneUp does not support the gamification of student actions performed in MOOC frequent activities such as interaction with learning contents (*e.g.*, video-watching), with course peers (*e.g.*, discussion forums) or other types of course assignments different than quizzes. Second, INDIeAuthor and MEdit4CEP-Gam do not support the gamification of MOOC platforms native tools, forcing both practitioners and students to use new tools decoupled from the contents and structures of MOOC platforms. Additionally, currently INDIeAuthor does not provide a graphical user interface for the configuration of gamified strategies, compromising its usability for non ICT-expert practitioners. Furthermore, the three systems present limitations in the design of gamified collaborative tasks that can be useful in MOOCs, and in their integration with external tools that are also frequently used in MOOCs.

All in all, results revealed a lack of gamification systems and gamified platforms supporting all the identified features associated to the design, instantiation and management of gamified MOOCs. Limitations associated to design expressiveness can hinder the digital representation of gamified MOOC learning designs and their automatic deployment and management. Given this situation, MOOC practitioners are forced to either manually instantiate and manage reward-based strategies (a non-affordable task in a course with hundreds or thousands of participants) or to adapt their gamification designs to the restricted design capabilities of current gamification systems. Otherwise, limitations in the design expressiveness can potentially constraint the design of gamification strategies aligned with course goals, the affordability and adoption of such strategies, and the attainment of the expected gamification benefits for learners.

It is worth mentioning that during the orchestration of reward-based strategies, practitioners can be supported in multiple forms. This dissertation have focused on those features that we considered important related to design expressiveness, practitioners' affordability and adoption and positive learners' experiences. However, there exist other topics (*e.g.*, intelligent gamification systems that provide personalized gamification) and features (*e.g.*, support in the gamification reflection phase) that were not considered and which could potentially target to practitioners' affordability and/or adoption. Future work would involve an analysis of other potential features affecting practitioners' orchestration of reward-based strategies and their support by current gamification systems.

4.3 GamiTool

The previous section showed the constraints of current gamification systems regarding their design expressiveness, practitioners' affordability and adoption, and learners' experience. In order to overcome such constraints, this chapter introduces GamiTool, a tool to support practitioners in the design, instantiation and management of reward-based strategies in MOOC environments. GamiTool development was principally guided by the

aforementioned features (see Section 4.2.2).

Those features associated to design expressiveness were mainly addressed by a data model (*i.e.*, GamiTool-DM, Section 4.3.1); those features associated to practitioners' affordability and adoption, by a system architecture (*i.e.*, GamiTool-ARCH, Section 4.3.2); and, those features associated to usability and positive user experiences (*i.e.*, practitioners and students), by the development of an usable prototype (Section 4.3.3). Although the iterative development of GamiTool spanned three consecutive cycles of the research methodology, this chapter describes the final version. This final version represents the second contribution of this dissertation (see *CONT#2_SYS* in Fig. 4.1), and its evaluation will be presented in Chapter 5.

4.3.1 GamiTool-DM: A Data Model for Flexible Gamified Learning Designs

The development of a data model considering the features used in the analysis (see Section 4.2.2) would allow the computer-interpretable representation of learning designs incorporating complex reward-based strategies in MOOC frequent activities, including multiple types of rewards and fine-grain conditions. Therefore, practitioners could apply multiple gamification purposes into different learning designs, and better align such intentions with the course goals (see *OBJ#2_EXP* in Fig. 4.1). Additionally, a computer-interpretable data model would enable the automatic or semi-automatic instantiation and management of reward-based decisions, thus reducing practitioners' workload and supporting affordability in these contexts (see *OBJ#3_AFF* in Fig. 4.1). Altogether, these benefits can eventually lead to increase the adoption of reward-based strategies in MOOC contexts.

The first step of the data model development was the identification of its requirements. Model requirements were derived from the previous features (see Table 4.6), which were obtained from both the literature, and from the self-experience during the provision of the empirical studies reported in Chapter 3. Requirements were then converted into abstract elements and attributes able to represent them. The resulting data model is presented using UML notation [93] in Figure 4.5.

For a better comprehension of the data model, its elements have been classified into six different categories: *users*, *learning designs*, *gamification designs*, *gamification conditions*, *gamification rewards* and *MOOCs*. During this section, the most relevant elements and attributes are summarized and illustrated with some examples.

Users

This category (white color in Fig. 4.5) includes all the elements associated to stakeholders interacting with reward-based strategies during the lifecycle of a gamified MOOC. The two main stakeholders involved in this gamification process are *Practitioners* and *Students*.

- *Practitioners* are responsible for the MOOC creation, including its gamified learning design. One practitioner can participate in multiple MOOCs, and one MOOC can involve multiple practitioners.

Features	Requirements
[DE1] Multiple types of rewards	The model should support multiple types of rewards including badges, points and levels.
[DE2] MOOC in-course privileges	The model should support MOOC in-course privileges in MOOC frequent resource types.
[DE3] Previous earned rewards	The model should support conditions based on previous earned rewards.
[DE4] MOOC frequent activities	The model should support conditions based on student actions within MOOC frequent activities.
[DE5] Fine-grain rules	The model should support the configuration of fine-grain conditions based on student actions within MOOC frequent activities.
[DE6] Group conditions	The model should support conditions based on group student actions.
[DE7] Peer approval	The model should support conditions based on peer subjective assessment.
[DE8] Configurable associations	The model should provide flexibility to connect rewards with conditions without any restriction.
[PA1] MOOC-technology independent	The model should be independent from MOOC platforms' models.
[PA2] Integration with external tools	The model should support conditions and course privileges over third party tools.
[PA4] Analytics support	The model should record student actions related to course gamification useful for practitioners.
[PA6] Automated issuing procedure	The model should store all relevant information to provide automated management during course run-time.
[PA8] Automated deployment	The model should store all relevant information to provide automated deployment of the configured gamification design.
[LE2] Claiming/Disable option	The model should store student preferences toward gamification.

Table 4.6: GamiTool-DM requirements. Requirements addressed by other GamiTool sub-elements have been excluded from this table for better comprehension ([PA3],[PA5],[PA7],[LE1],[LE3]).

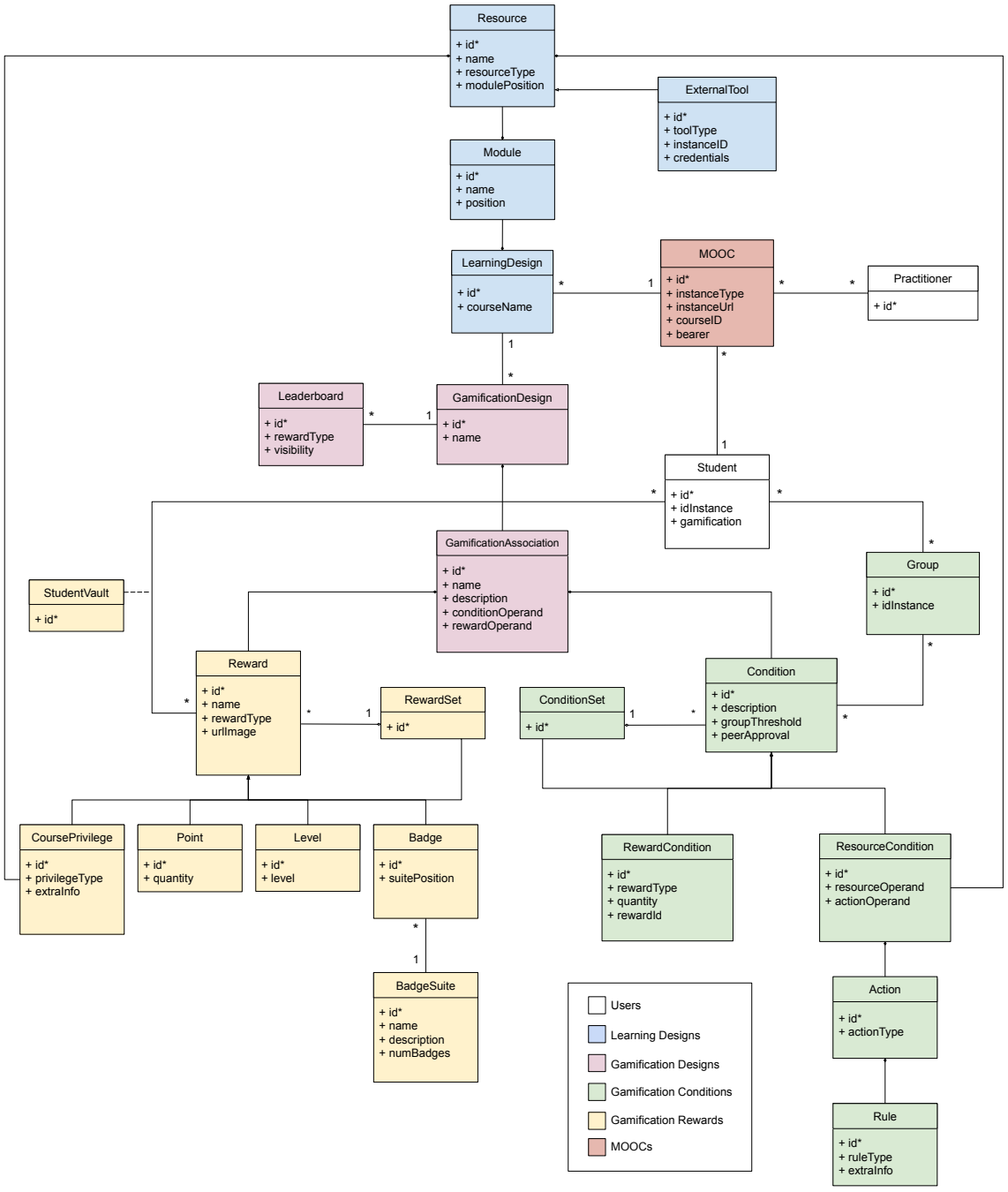


Figure 4.5: Overview of the proposed data model using UML notation.

- *Students* are the MOOC participants interacting with the deployed reward-based strategies in a single course. The *gamification* parameter stores the student decision of whether gamification will be activated for him/her. Besides, the *idInstance* parameter stores the student identifier in the MOOC platform to eventually retrieve information to (a) understand whether gamification conditions were satisfied, and (b) provide course and gamification analytics in the eventual system implementing the data model. The *Reward* relationship identifies and keeps record of the already claimed and issued rewards that will be stored in the *StudentVault* element.

Learning Designs

This category (blue color in Fig. 4.5) involves the elements associated to the representation of the learning design that is being gamified. The conditions and course privileges that can be configured in a gamification design refer to the specific resources and tools that are contained in the learning design. Consequently, this category refers to those learning design components typically supported by current MOOC platforms, over which we will provide a flexible layer of reward-based strategies.

- *LearningDesigns* represent course designs over which *GamificationDesigns* can be created. Learning Designs are structured in *Modules* that help organize the course resources into different learning units.

- *Resources* are course objects (*e.g.*, self-contained videos, documents) and tools (*e.g.*, discussion forums, quizzes) located in the different *Modules* of the *LearningDesigns*. While the *resourceType* parameter identifies the type of object or tool, the *modulePosition* parameter designates the position of such resource within the module container. The type of resource establishes the type of course privilege (*CoursePrivilege*) that can be applied and the type of action that can be configured as condition in such resource (*ResourceCondition*). For instance, a *deadline extension* privilege can be applied in resources such as quizzes or assignments but cannot be applied to objects (*e.g.*, *videos, documents*) or to specific tools (*e.g.*, *discussion forums, content pages*). Similarly, a *submit* action can be applied to resources such as quizzes or assignments but cannot be applied to objects or to specific tools. The full list of resource types supported by the model is presented in Appendix C.1.

- The *ExternalTool* element includes additional attributes to represent and gamify those activities expected to be performed in third-party tools in relation with the MOOC platform. For example, Google Spreadsheets would be considered an *ExternalTool* with respect to the edX MOOC platform. Practitioners need to provide information about the *toolType* (*e.g.*, video-conference tool, social-media tool), about their online location (*instanceID*) and about the credentials (*credentials*) that will enable the interaction between the system implementing the data model and the external tools (*e.g.*, ask whether reward conditions performed in such tools were satisfied for a concrete student).

Gamification Designs

This category (purple color in Fig. 4.5) represents the high-level information related to the gamification designs.

- *GamificationDesign* represents an entity to which *GamificationAssociations* can be added. Since one learning design could be gamified in different forms, the model allows the creation of multiple gamification designs over the same learning design.

- *GamificationAssociation* represents the relationship between *conditions* and *rewards*, *i.e.*, the conditions under which the rewards will be issued to the *Students*. In this context, multiple rewards can be issued under a single condition and, conversely, one single reward can be issued under multiple conditions. Gamification associations contain a *name* and a *description* describing the conditions and rewards of such association, thus engaging students to earn them. Additionally, the *conditionOperand* and *rewardOperand* parameters (*e.g.*, all, any) allow to configure complex reward-condition associations.

- The *Leaderboard* element allows the configuration of rankings within the gamification design. Multiple leaderboards can be added to a gamification design considering the different types of rewards (*e.g.*, points, badges). Additionally, the *visibility* parameter would allow practitioners to decide whether student names will be anonymously displayed in such leaderboards.

Gamification Rewards

This subcategory (yellow color in Fig. 4.5) belongs to the 'Gamification Designs' category and represents the information associated to course rewards. Individual *Rewards* share some optional parameters such as *name*, *image*, *quantity* or *reward_type*. In this model, the top three rewards used in online environments have been explicitly included (*Points*, *Badges* and *Levels*) together with *CoursePrivileges*, thus supporting the two design expressiveness requirements related to course rewards ([DE1] and [DE2]). However, the data model could be easily extended to other types of rewards (*e.g.*, trophies, ribbons) either by mapping these reward types to existing elements (*e.g.*, *Points*) or by defining the reward type and creating a new class inherited from the *Reward* class.

- *Points* and *Levels* are the simplest types of reward. These rewards can be associated to a *quantity* (*e.g.*, 1000 points), a *name* (*e.g.*, Level 5: Master) and an *image* (*e.g.*, coins), parameters already defined in the *Reward* element.

- *Badges* are visual representations of rewards which usually have an associated a name and image. However, differently from points and levels, badges with similar conditions are sometimes grouped into *BadgeSuites* (*e.g.*, bronze, silver, gold). The *numBadges* and *suitePositions* parameters allow to define the number of badges and their position in the suite.

- *CoursePrivileges* are rewards that provide certain privilege during course run-time. Privileges need to define the type of privilege (*privilegeType*) and extra information

(*extraInfo*) if needed (*e.g.*, *type*: deadline extension, *extraInfo*: the new date and time). Course privileges can be associated to one or multiple *Resources* from the learning design. Depending on the type of resource selected for the privilege, the type of privilege that can be applied will vary (*e.g.*, extra time can be applied in quizzes, not in discussion forums). The full list of privilege types proposed to be supported by the model can be seen in Appendix C.4. Further privilege types could be easily added to the model by adding them to this list and identifying the resource types where can be applied.

- The *RewardSet* element permits the definition of *Rewards* composed by multiple rewards.

Gamification Conditions

This subcategory (green color in Fig. 4.5) belongs to the 'Gamification Designs' category and represents the information associated to reward conditions. Other condition types could be easily added to this model by including new classes inheriting from the *Condition* element and specifying the required parameters. The *Condition* element includes all the shared parameters among all different condition types including a *description* and a *groupThreshold*. The *Group* element allows to define *Student* groups that need to perform a group condition. If set, the *groupThreshold* attribute allows to define the minimum percentage of group members that have to satisfy the configured condition. If set, the *peerApproval* attribute allows the definition of conditions based on *Group* peer assessment.

- *RewardCondition* represents those conditions based on previous earned rewards (*e.g.*, level up when reaching 1000 points). The *rewardType* allows to select the reward type of the condition and the *quantity_lo* and *quantity_hi* parameters, the thresholds. Besides, a *rewardId* parameter was added to allow setting as a condition the attainment of a concrete reward (*e.g.*, level up when 3 concrete a badge is earned).

- *ResourceCondition* represents those conditions based on individual actions performed within the course contents and tools. Resource conditions need to be associated with *Resources* from the learning design identifying the object or tool where the action has to be performed. The *resourceOperand* allows to decide whether the condition will be performed in the selected resource (this), in all the resources of the same type (all), or in any resource of the same type (any) (*e.g.*, receive 20 likes in the different discussion forums of the course). Two more elements were added to represent fine-grain conditions:

  - *Action* represents the specific actions that student must complete to accomplish the condition for the selected resource (*e.g.*, view, submit or mark as done a course quiz). The *actionType* parameter identifies the action itself which depends on the resource type that is being gamified. For instance, 'post an entry' (action type) cannot be configured in a course questionnaire (resource type)

but in a discussion forum (resource type). The full list of action types proposed to be supported by the model can be seen in Appendix C.2. The *actionOperand* parameter from the *ResourceCondition* element allows the configuration of multiple actions for a single resource.

  - *Rule* allows to define more detailed conditions within the selected action type. The *ruleType* parameter can be used to configure fine-grain resource conditions such as doing the action several times, before a specific date, or getting an equal or higher score than a given value. The provided value for such rules will be stored in the *extraInfo* parameter. The full list of rule types proposed to be supported by the model can be seen in Appendix C.3.

- The *ConditionSet* element permits the definition of *Conditions* composed by multiple conditions.

MOOCs

This category (red color in Fig. 4.5) contains persistent information needed to automatically or semi-automatically interact with the MOOC to be gamified. The *instanceType* (*e.g.*, Canvas, Open edX), *instanceURL* (*e.g.*, learn.canvas.net, ou.edia.nl) and *courseID* parameters identify such course. Additionally, practitioners need to provide an authorization token (*bearer*) granting their role in the course and allowing automatic interactions. These interactions involve (a) the automatic pull of the MOOC learning design (including modules and resources) into the gamification system (see *LearningDesign* relationship), (b) the automatic deployment of the configured gamification design, and (c) the automatic handling of reward claims (see *GamificationDesign* relationship). All these automatic interactions target practitioners' affordability and adoption of gamification in MOOCs.

4.3.2 GamiTool-ARCH: A System Architecture for Gamified Learning Designs

While the model proposed in the previous subsection mainly helped to overcome the design expressiveness limitations of previous systems, the system architecture focuses on those features identified in the analysis of Section 4.2 that are related to practitioners' affordability and adoption of reward-based strategies. Table 4.7 presents the GamiTool requirements associated to architectonic components, and the design decisions considered to satisfy them. In brief, the architecture has been divided into two subsystems (*i.e.*, *Design & Instantiation* and *Management* subsystems) implementing a two-layer structure with loosely-decoupled adapters allowing the integration with multiple MOOC platforms (or virtual learning environments) and external tools through pre-established contracts (see Fig. 4.6).

The *Gamification Design & Instantiation* subsystem supports the authoring of gamification designs, instantiating them into MOOC platforms and storing them in a system database. The *Gamification Management* subsystem handles students' reward requests and the associated procedure to manage them. Finally, the tool contracts describe a set

Features	Requirements	Design Decisions
[DE] Design expressiveness	GamiTool should support practitioners to digitally represent their gamification designs with GamiTool-DM	GamiTool architectonic subsystems implement GamiTool-DM and access to a database storing such designs.
[PA1] MOOC-tech. independent	GamiTool should allow the conversion of information represented with GamiTool-DM to the language supported by MOOC platforms and vice-versa.	An adapter-based layer between the subsystems implementing GamiTool-DM and the considered MOOC platforms.
[PA2] Integration with external tools	GamiTool should allow the conversion of information represented with GamiTool-DM to the language supported by third-party tool and vice-versa.	An adapter-based layer between the subsystems implementing GamiTool-DM and the considered external tools.
[PA3] Usable for practitioners	GamiTool should make the orchestration of reward-based strategies as usable as possible.	GamiTool architectonic subsystems incorporates graphical user interfaces. Additionally, the architecture incorporates components to ease the orchestration of these strategies (*e.g.*, LD import).
[PA5] Changes during enactment	GamiTool should allow the edition of the gamification learning design during course run-time.	Gamified learning designs are stored in a shared database among GamiTool subsystems.
[PA6] Automated issuing procedure	GamiTool should automatically handle the reward issuing procedure including the course privilege application.	A subsystem handling the reward requests, querying the gamification design, storing the rewarding information and applying the course privileges.
[PA8] Automated deployment	GamiTool should automatically deploy the configured learning designs.	The authoring tool subsystem connects with MOOC platforms to insert a gamification page pointing to the configured gamification learning design.
[LE1] Gamification seamless integration	GamiTool should provide a seamless integration between MOOC platforms and gamification systems.	The management subsystem collects the MOOC platform students' identifiers when accessing to the gamification system.

Table 4.7: GamiTool-ARCH requirements. Requirements not associated with the system architecture have been excluded from this table for better comprehension.

of expected behaviors (*e.g.*, the provision of the requested information) that MOOC platforms and external tools have to implement to communicate with both subsystems [98]. The different components of the architecture and their functionality can be presented with more detail in the following scenario.

In the life-cycle of a regular MOOC (see upper part of Fig. 4.6), practitioners login into the MOOC platform, upload the course contents (*e.g.*, self-contained videos, documentation), configure the course structure, the activities and the (native and external) tools that will be used in the course (*e.g.*, Facebook, Zoom, Google Spreadsheets). Once configured, practitioners are ready to configure the reward-based strategies according to the resources and tools implemented in the learning design. Given this situation, the *Gamification Design & Instantiation* subsystem can retrieve existing learning designs from MOOC platforms to make this process more timely and cognitively affordable (see *LD request* in Fig. 4.6). To this end, *MOOC Platform Adapters* are responsible of retrieving and translating MOOC learning designs from the native language of MOOC platforms to the data model supported by the *Gamification Design & Instantiation* subsystem (*i.e.*, GamiTool-DM).

Once gamification designs are imported into GamiTool, practitioners can gamify them according to their preferences by using the GUI of the *Design & Deployment* subsystem. In case of implementing conditions or privileges involving external tools, practitioners should also insert the required information of such systems (*e.g.*, tool instance url, shared secret). In this context, learning designs and gamified learning designs must be stored in a shared database (*Designs & instantiations*), also accessible from the *Gamification Management* subsystem during course run-time. Additionally, in order to instantiate the configured design into the course, practitioners must provide contextual information about the MOOC (*e.g.*, MOOC platform url, authentication bearer) to automatically insert a gamification page in the course, pointing to such design in the *Gamification Management* subsystem. The gamification page should provide to the *Gamification Management* subsystem the students' identifiers when interacting with the gamification page, thus avoiding students to re-login in the gamification system. Additionally, the gamification page should offer to students the possibility of claiming the configured rewards, thus avoiding bother those students not interested in course rewards.

During course run-time, the *Gamification Management* subsystem should automatically handle the reward claims. When students visit the gamification page, the MOOC platform provides information about the student who is accessing. The *Gamification Management* subsystem will display different GUIs for the different roles. In case of students, the *Gamification Management* subsystem will identify in the database the rewards already earned by such student, allowing her to claim the ones that were not earned before. In case of practitioners, the subsystem will provide gamification analytics, supporting problem identification and gamification evaluation during course run-time and afterwards. If the gamification design needs to be modified, practitioners would just need to change the design with the GUI of the *Gamification Design & Instantiation* subsystem, without the need of deploying the gamification design again.

When a student claims a reward, the *Gamification Management* subsystem requests the specific information to understand whether the conditions to earn such reward were satisfied by the student. To this end, *MOOC Platform Adapters* or *External Tool Adapters*

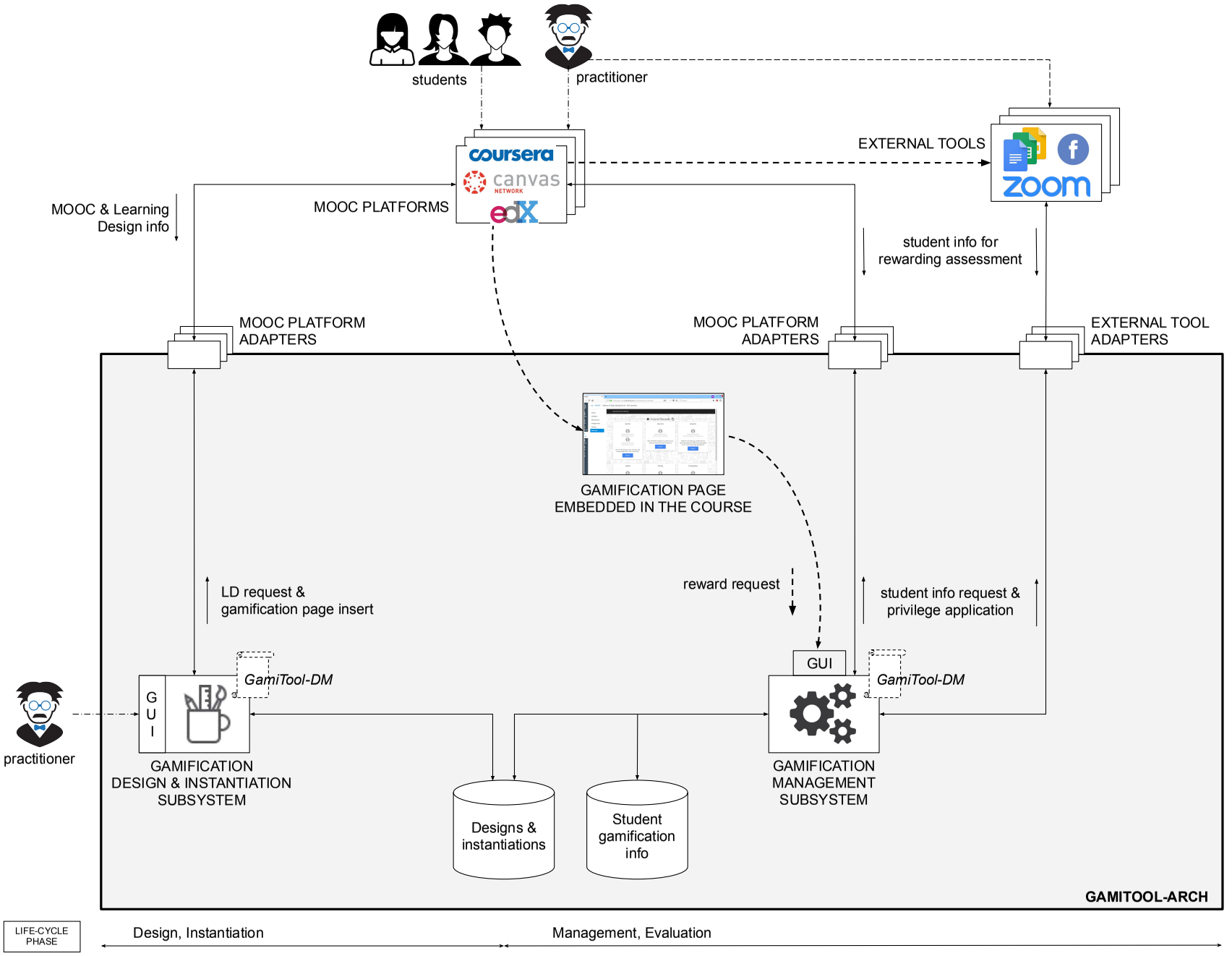


Figure 4.6: Overview of GamiTool-ARCH.

are responsible of querying the platform or tool according to the pre-established contracts. If conditions were satisfied, the *Gamification Management* system will issue the reward to the student by recording it in the *Student gamification info* database and displaying it in the gamification page. Furthermore, in case of applying course privileges (*e.g.*, extra attempts, deadline extensions), the *Gamification Management* subsystem should automatically redeem such privileges through the *MOOC Platform Adapters*. For non-automatable privileges (*e.g.*, submission revised by the instructor, video-session with the instructor), the *Gamification Management* subsystem facilitates the realization of such privileges (*e.g.*, the provision of the links to the video-sessions). For instance, the creation of a meeting room with the Zoom video-conference external tool whose link is embedded in the instructor and student section to facilitate the process of enacting the course privilege.

4.3.3 GamiTool prototype

The development of a system prototype served to: (1) demonstrate the feasibility of the proposals (*i.e.*, GamiTool, GamiTool-DM, and GamiTool-ARCH); (2) complete the requirements identified as important to support practitioners' affordability and adoption and promote positive learners' experiences (see Table 4.8); and (3) evaluate their functionality in real world settings (see Chapter 5). Additionally, the prototype development process helped to gain insights about the system features and its refinement.

GamiTool was developed as a web-based tool following the Model/View/Controller (MVC) pattern. Web-based applications are stored and run on online servers using a client-server architecture. These applications do not require previous installation and work over every operative system and Internet navigator (including mobile devices), thus having the same requirements as those of MOOC platforms. MVC is a software design pattern that divides the logic of the system into three interconnected elements [153]. MVC is widely adopted in web-based applications supporting the division of tasks between the client and the server [158]. Among other benefits, MVC supports modules' high cohesion by grouping related logic functions on the same controller, and loose coupling among views, models and controllers, allowing to easily replace and adapt them to new functionalities and requirements (*e.g.*, database technology, new visual displays).

The client-side (*i.e.*, front-end) was developed in HTML5, CSS, AJAX, and JavaScript. The server-side (*i.e.*, back-end) was developed in PHP under the Laravel framework. PHP is a widely-used open source scripting language suited for web-based applications that can be embedded into HTML[4]. Laravel is an open-source PHP web framework intended for the development of web-based applications following the MVC pattern[5]. During the development process, GitHub[6] was used as a project repository and management system, and PHPStorm[7] as the integrated development environment. Both the database and the graphical user interfaces have been refined through iterative cycles of design with beta-testers and TEL-experts according to the features identified as relevant in this dissertation.

[4]The PHP Group. What is PHP? Retrieved from: *https://www.php.net/manual/en/intro-whatis.php*, last access: September, 2020.

[5]Laravel LLC. Laravel. Retrieved from: *https://laravel.com/*, last access: September, 2020.

[6]GitHub: *https://github.com/*, last access: September, 2020.

[7]JetBrains, PHPStorm: *https://www.jetbrains.com/phpstorm/*, last access: September, 2020.

Features	Requirements	Design Decisions
[PA1] MOOC-tech. independent	GamiTool should allow the conversion of information represented with GamiTool-DM to the language supported by MOOC platforms and vice-versa.	To demonstrate the feasibility of the MOOC platform adapters, the prototype implements adapters for at least two different MOOC platforms.
[PA2] Integration with external tools	GamiTool should allow the conversion of information represented with GamiTool-DM to the language supported by third-party tool and vice-versa.	To demonstrate the feasibility of the external tool adapters, the prototype implements adapters for at least two different third-party tools.
[PA3] Usable for practitioners	GamiTool should make the orchestration of reward-based strategies as usable as possible.	A web-based prototype integrating graphical user interfaces allow the design, instantiation, management and evaluation of reward-based strategies. To this end, graphical interfaces are developed using the design guidelines proposed by Albert & Tullis (2013) [5].
[PA4] Analytics support	GamiTool should provide practitioners with gamification analytics during course run-time and a posteriori.	Practitioner visual interfaces display gamification analytics during course run-time and a posteriori.
[PA7] Evidence of support with large cohorts	GamiTool should implement robust and efficient database technologies, supporting a massive number of concurrent accesses in short periods of time.	The prototype implements postgreSQL database technology.
[LE1] Gamification seamless integration	GamiTool should provide a seamless integration between MOOC platforms and gamification systems.	The implementation of the IMS LTI compliant interface enables a single sign-in process to access the system.
[LE2] Claiming/ Disable option	GamiTool should allow students to active/deactivate the gamification features.	Student interface includes bottoms to activate and deactivate the gamification page, and to claim the rewards.
[LE3] Usable for learners	GamiTool should make the interaction with reward-based strategies as usable as possible.	A web-based prototype integrating graphical user interfaces developed using the design guidelines proposed by Albert & Tullis (2013) [5].

Table 4.8: Prototype requirements. Requirements not associated with the prototype have been excluded from this table for better comprehension.

Feature	GamiTool-DM	GamiTool-ARCH	GamiTool
[DE1] Multiple types of rewards	+		+
[DE2] MOOC in-course privileges	+		+
[DE3] Previous earned rewards	+		+*
[DE4] MOOC frequent activities	+		+
[DE5] Fine-grain rules	+		+
[DE6] Group conditions	+		+*
[DE7] Peer approval	+		+
[DE8] Configurable associations	+		+
[PA1] MOOC-technology independent	+	+	+
[PA2] Integration with external tools	+	+	+*
[PA3] Usable for practitioners		+	+
[PA4] Analytics support	+	+	+
[PA5] Changes during enactment		+	+
[PA6] Automated issuing procedure	+	+	+
[PA7] Support with large cohorts			+
[PA8] Automated deployment	+	+	+
[LE1] Gamification seamless integration		+	+
[LE2] Claiming/Disable option	+		+
[LE3] Usable for learners			+*

Table 4.9: Summary of the features supported by GamiTool. * indicates features considered in the design but not implemented or evaluated in the GamiTool prototype.

An updated version of the GamiTool project can be found in [8]. Additionally, the GamiTool source files can be downloaded from [9]. A set of GamiTool screenshots have been added to Appendix D. An extended version[10] of GamiTool was used in the third empirical study described in this dissertation (see Section 3.3), thus supporting its feasibility and applicability in MOOC real scenarios.

4.3.4 Discussion

During this section, the important features of gamification systems and MOOC platforms for the design, instantiation and management of reward-based strategies in MOOCs served to create a set of system requirements. These requirements guided the design of the three subcomponents of GamiTool: GamiTool-DM, which mainly helped to satisfy the requirements associated to design expressiveness; GamiTool-ARCH, which mainly helped to fulfill the requirements associated to practitioners' affordability and adoption; and, the prototype, that shows the feasibility of the previous subcomponents, and addressed those

[8] GamiTool: *https://dev-gamitool.gsic.uva.es/*, last access: September, 2020.

[9] GamiTool project: *https://www.gsic.uva.es/gamitool/*, last access: September, 2020.

[10] GamiTool implementing several ad-hoc modules to extend their functionality for research purposes (*e.g.*, functionalities supporting multiple experimental groups).

requirements associated to system usability and positive learners' experiences. This section discusses the extent to which the identified features and their associated requirements were satisfied by the different subcomponents, and their design decisions (see Table 4.9).

GamiTool-DM provides practitioners with a data model to create MOOC learning designs involving reward-based strategies with full design expressiveness according to the features identified as important. Additionally, GamiTool-ARCH incorporates GamiTool-DM into their subsystems to support the realization of practitioners' tasks associated to reward-based strategies such as the automation of the reward issuing procedure. The developed prototype included both subcomponents, providing practitioners with an authoring tool to design MOOC learning designs incorporating reward-based strategies. In this context, although all design expressiveness features were considered for the design of GamiTool-DM, two of them were not implement in the final prototype due to time restrictions and the priorization of other development tasks essential for demonstrating GamiTool feasibility and evaluation. The following list summarizes how all these features are satisfied by GamiTool:

DE1. **[R] Multiple types of rewards.** GamiTool-DM supports multiple types of *Rewards* including *Badges*, *Levels*, *Points* and *Course Privileges* thanks to the elements included in the *Gamification Reward* category. Additional reward types could be easily incorporated to the model by identifying the distinctive attributes and adding them to a new element inheriting from the *Reward* element.

DE2. **[R] MOOC in-course privileges.** GamiTool-DM supports the use of *Course Privileges* and provides a set of configurable privileges depending on the target resource type, including: content pages, discussion forums, quizzes, assignments, and peer reviews (MOOC frequent tools and activities). A list of the supported course privileges can be found in Appendix C.4. Additional privileges could be added to the model by registering the new privilege type, and the types of resources where this privilege can be applied. Then, the tool contract of MOOC platform and external tool adapters should incorporate those functions to actually apply the privilege into the courses.

DE3. **[C] Previous earned rewards.** The *RewardCondition* element allows the configuration of conditions based on previous earned rewards. In GamiTool-DM, previous rewards can refer either to a specific reward (*rewardId* parameter) or to a cumulative number of the same reward type (*rewardType* and *quantity* parameters), as shown in literature. The model also includes the *StudentVault* element that stores the previous earned rewards of each student, thus helping to automate the rewarding process of this type of condition.

DE4. **[C] MOOC frequent activities.** The *ResourceCondition* element allows the configuration of conditions associated to individual actions performed within the different resources (and resource types) configured in the LD including videos, content pages, discussion forums, quizzes, assignments and peer reviews. A list of the supported resource types can be found in Appendix C.1. Additional resources could be added by registering the new resource type and their association with course privileges and student actions that could be used as conditions in such resource type.

DE5. **[C] Fine-grain rules.** GamiTool-DM supports the definition of personalized fine-grain conditions according to the *Action* and *Rule* types given, and to the *actionOperand* and *rewardOperand* parameters. Therefore, practitioners can configure multiple parameters for the same condition according to their purposes (*e.g. making a quiz submission before a specific date scoring higher than 90%)*. A list of supported actions and rules can be found in Appendix C.2 and Appendix C.3. Additional actions and rules could be added by registering them and their association with the resource type where they could be performed. Then, the tool contract of MOOC platform and external tool adapters should incorporate those functions to actually apply the privilege into the courses.

DE6. **[C] Group conditions.** GamiTool-DM includes the *Condition* element which allows the configuration of conditions that have to be satisfied by a minimum number of students (*groupThreshold* attribute) belonging to the same *Group*.

DE7. **[C] Peer approval.** In GamiTool-DM, when the *peerApproval* attribute is set, the *Condition* refers to peer assessment by a minimum number of students (*groupThreshold* attribute) belonging to the same *Group*. Conditions involving peer approval (for all course participants) can be also configured through *conditions based on individual actions performed in MOOC frequent activities* in a discussion forum.

DE8. **[A] Configurable associations.** The *GamificationAssociation* element included in GamiTool-DM allows the combination of one or multiple rewards with one or multiple conditions as configured by practitioners. Besides, both rewards and conditions can be personalized (considering the previous features) according to practitioners' preferences.

GamiTool-ARCH was mainly designed to support practitioners' affordability and adoption of reward-based strategies in their MOOC teaching practice. However, it is important to mention that different design decisions considered in the development of GamiTool-DM and the prototype also contributed to the achievement of this aim:

PA1. **MOOC-technology independent.** GamiTool is intended to be used within multiple MOOC platforms. To this end, GamiTool implements GamiTool-ARCH and GamiTool-DM. On the one hand, GamiTool-DM allows the representation of MOOC learning designs regardless the MOOC platform for which the design is intended for. On the other hand, the two-layer architecture implementing loosely-decoupled adapters allows the integration with multiple MOOC platforms through pre established contracts.

The developed prototype included MOOC platform adapters for courses placed in Canvas and Moodle instances. These adapters implemented existing Canvas[11] and Moodle[12] PHP clients to support the connection between such instances and the Gamitool subsystems (*e.g.*, pagination of information). Figure D.7 and Figure D.8

[11] cesbrandt/canvas-php-curl: *https://github.com/cesbrandt/canvas-php-curl*, last access: September, 2020.

[12] ozq/moodle-client: *https://github.com/ozq/moodle-client*, last access: September, 2020.

show the result of deploying a gamification learning design created with GamiTool into Canvas and Moodle instances respectively. More adapters could be developed under request to connect GamiTool with other MOOC platforms. Nevertheless, one limitation of this architectural approach is that some commercial MOOC platforms (*e.g.*, MiriadaX[13]) and external tools, lack mechanisms for platform interaction (*e.g.*, API, LTI). Thus, the satisfaction of such pre-established contracts cannot be reached and therefore, gamification of such platforms and tools cannot be supported by this architecture.

Another limitation of technology-independent models is the possibility of loosing information during the data conversion from GamiTool to the MOOC platform and vice-versa. For instance, MOOC platforms could incorporate activity types not supported by GamiTool-DM (*e.g.*, glossary), and therefore, when importing the learning design, this type of activity will not be understood by GamiTool. On the contrary, this approach permits the use of GamiTool within multiple MOOC platforms, thus fostering their use and adoption for a broader number of MOOC practitioners.

PA2. **Integration with external tools.** GamiTool is intended to be used with multiple third-party tools. To this end, GamiTool implements GamiTool-ARCH and GamiTool-DM. On the one hand, GamiTool-DM allows the representation of third-party tools within learning designs (*ExternalTool* element), thus supporting their association with course privileges and resource conditions). On the other hand, the two-layer architecture implements loosely-decoupled adapters to allow the run-time management of such privileges and conditions. For the prototype, we developed one ad-hoc adapter for the Google Spreadsheets tool (see * in Table 4.9). More adapters can be developed under request to connect GamiTool with other third-party tools. The only restriction, as already mentioned, is that third-party tools enable external connections.

PA3. **Usable for practitioners.** GamiTool integrates multiple graphical user interfaces including those intended to author gamified learning designs. These graphical interfaces were designed following the guidelines proposed by Albert & Tullis (2013) [5] to make them usable for the design, instantiation and management of reward-based strategies. Additionally, GamiTool-ARCH provides a set of properties making the use of reward strategies simple: the automatic learning design importation, the automatic gamification deployment and the automatic handling of the reward issuing. As presented in Chapter 5, MOOC practitioners and gamification designers confirmed the high usability of GamiTool.

PA4. **Analytics support.** GamiTool provides practitioners with information about learners' gamification experience (*e.g.*, number of rewards claimed and issued, top issued students) during course run-time and afterwards. Given this context, GamiTool interprets, processes and presents GamiTool-DM parameters storing relevant information about the learners' gamification experience. To this end, GamiTool incorporates dashboards presenting such information for gamification deployments (see

[13]MiriadaX: *https://miriadax.net/home*, last access: September, 2020.

Fig. D.6). Furthermore, the IMS LTI standard integrated in the gamification section of the course allows to identify the role of the participant that is accessing to the gamification page inserted in the course. In case of practitioners, the *Gamification Management* subsystem provides these dashboards inside the course to allow them monitor the student interaction with rewards during course run-time and afterwards.

PA5. **Changes during enactment.** GamiTool enables the edition of the gamification design during course run-time to adapt it according to the MOOC situation (*e.g.*, number of participants, conditions difficulty). To this end, GamiTool incorporates GamiTool-ARCH and enables the edition of the gamification design with the authoring tool once the design has been deployed (see Fig. D.3). Additionally, the edited gamification learning design does not require to be deployed again since the new gamification design overrides the previous one and reuses the same URL.

PA6. **Automated issuing procedure.** GamiTool implements GamiTool-ARCH allowing the automatic handling and issuing of configured rewards after a reward claim. To this end, GamiTool incorporates all functionalities related to this automatic process including the request for information, the condition requirement verification, the application of course privileges and the information storage. The *MOOC* element included in GamiTool-DM stores useful information (*instanceType*, *instanceURL*, *courseId*, and *bearer*) supporting the gamification management during course run-time, including the issuing procedure. Practitioners would need to provide this information beforehand.

PA7. **Evidence of support with large cohorts.** Due to the massive number of participants in MOOCs and therefore, to the potential number of concurrent interactions with the gamification elements, GamiTool implements a quick read-write database technology. To this end, the prototype implemented PostgreSQL[14], an open-source object-relational database system able to scale to high data workloads. This technology worked efficiently for the *TraduMOOCv2* course which registered 866 enrolled students. However, further investigation would be needed to test its efficiency for courses involving thousands of enrolled students.

PA8. **Automated deployment.** GamiTool implements GamiTool-DM and GamiTool-ARCH allowing the automatic deployment of GLDs once practitioners confirmed it. On the one hand, the *MOOC* element included in GamiTool-DM stores the information needed to support the interaction with the MOOC platform: *instanceType*, *instanceURL*, *courseId*, and *bearer*. Practitioners would need to provide this information beforehand. On the other hand, the *Gamification Design & Instantiation* subsystem is responsible of converting the gamified learning design into a webpage that is inserted inside the configured MOOC.

Finally, GamiTool subsystems and the developed prototype contributed to the satisfaction of the features intended for promoting positive learners' experiences:

[14]PostgreSQL Development Group: *https://www.postgresql.org/about/*, last access: September, 2020.

LE1. **Gamification seamless integration.** GamiTool provides a seamless integration between the MOOC platform and the gamification system. To this end, GamiTool implements the LTI standard, thus identifying the participants that are accessing to the gamification section without the need of re-login into the gamification system.

LE2. **Claiming/Disable option.** GamiTool learners' interface provides them the option to enable/disable the gamification features and/or buttons to allow claim the concrete rewards they are interested to. To this end, GamiTool learner interface was configured with one button per reward (see Fig. D.7 and Fig. D.8) to enable those participants interested on gamification to claim them, and to avoid bothering those students not motivated by gamification elements. Additionally, the *Student* element in GamiTool-DM stores the students' decisions regarding this feature.

LE3. **Usable for learners.** GamiTool provides a graphical interface usable for MOOC learners. Gamification pages were proposed to be simple, including information about course rewards, buttons to claim them and to show a course leaderboard. To this end, GamiTool graphical interfaces were designed following the guidelines proposed by Albert & Tullis (2013) [5]. Due to time restrictions, this feature could not be evaluated by real MOOC participants. As a future work, we plan to incorporate GamiTool in future MOOCs and evaluate the usability of the system from the student perspective.

4.4 Conclusions

The systematic feature analysis described in this chapter helps to answer the research question posed in Section 4.2: *To what extent current systems provide support to the design, implementation and management of reward-based gamifications in MOOCs?* The feature analysis identified a limited number (5) of systems and MOOC platforms intentionally developed for the use of reward-based strategies in MOOC contexts and a limited number (3) of systems developed for the use of reward-based strategies in other environments different than MOOCs. Results from the feature analysis showed that most of these systems provide functionality to configure multiple types of rewards, have been tested in real environments and support the automatic rewarding process. However, gamification systems explicitly and non-explicitly developed for MOOC contexts, presented two important limitations: (a) a limited design expressiveness for MOOC contexts (*e.g.*, configuration of conditions with fine-grain rules in MOOC native tools, group-based conditions), that can hinder the attainment of the gamification purposes and their relationship with the MOOC pedagogical resources; and (b) a lack of technological support (*e.g.*, integration with external tools, MOOC-technology independent), that can affect the affordability and adoption of reward-based strategies in these contexts. Additionally, results showed that most complete systems according to the features identified (*i.e.*, OneUp, INDIeAuthor and MEdit4CEP-Gam), were not originally intended for MOOC environments, thus lacking important features for their gamification (*e.g.*, gamification of MOOC native tools, conditions based on peer approval).

In order to help overcome such identified limitations, this chapter introduces GamiTool, a gamification system to support practitioners in the design, instantiation and management of reward-based strategies in MOOCs (*CONT#2_SYS*). The system is formed by two components: a data model (*i.e.*, GamiTool-DM) and an architecture (*i.e.*, GamiTool-ARCH). The development of the system components was guided by a set of requirements derived from the features identified in the feature analysis. While the data model aimed to overcome the design expressiveness requirements, the architecture and the implemented prototype focused on those requirements associated to practitioners' affordability and positive learners' experiences. With the satisfaction of previous requirements, the developed prototype is a proof-of-concept of the proposed system.

Chapter 5

Evaluating GamiTool with MOOC Practitioners

Summary: This chapter undertakes the evaluation of GamiTool (including GamiTool-DM and GamiTool-ARCH). The evaluation consisted of two studies that helped refine the proposals and assess the level of accomplishment of the dissertation goals. The first study involved one MOOC practitioner who used GamiTool to design, instantiate and manage reward-based strategies in a real MOOC. The second study involved 19 MOOC practitioners and/or gamification designers who used GamiTool to design and instantiate a gamification design. The results of these evaluation studies showed the accomplishment of the second and third dissertation goals, and relevant directions for future research regarding the orchestration of reward-based strategies in MOOC environments.

5.1 Introduction

In the previous chapter, the GamiTool system, implementing both GamiTool-DM and GamiTool-ARCH, was proposed to help overcome the limitations identified in the systematic feature analysis. The last stage of the SDRM methodology involves the experimentation, observation and evaluation of the system. Once a prototype is developed, its performance, usability and impact on individuals and groups can be tested according to the purposes and objectives defined during the earlier stages [201]. GamiTool was developed to attain the second and third objective of this dissertation[1]:

OBJ#2 *To enable the computer-interpretable representation of MOOC learning designs involving reward-based strategies according to practitioners' decisions.*

OBJ#3 *To make cognitively and timely affordable for practitioners the design, instantiation and management of reward-based strategies in MOOCs.*

The SDRM methodology considers the evolutionary nature of system development. For this reason, the results from the evaluation phase can also help identify new requirements and provide insights to refine the proposed system. In this dissertation, one evalu-

[1]For the sake of clarity, the first objective of this dissertation was evaluated in Chapter 3.

ation study was carried out at the end of the first (*Cycle 1*) and second (*Cycle 2*) methodological iteration (see Fig. 1.2). Apart from the expected insights that were gathered to refine the system, results from these evaluations helped us know the extent to which GamiTool attains the posed dissertation objectives.

Next, Section 5.2 describes the first study which involved the evaluation of an initial version of GamiTool, which was used for the design, instantiation and management of a real MOOC (TraduMOOCv2) by its main course instructor. Section 5.3 describes the second study which involved the evaluation of a refined version of GamiTool regarding the design and instantiation of a MOOC involving reward-based strategies by 19 different MOOC practitioners and/or gamification designers. Finally, some general conclusions obtained from both evaluations are outlined in Section 5.4.

5.2 First Evaluation

This first evaluation consisted in the design, instantiation and management of reward-based strategies in TraduMOOCv2 by its main instructor. This way, this evaluation covered the full life-cycle of gamified learning activities, and thus, helped identify how the tool supported this life-cycle and which improvements were needed to fulfill the dissertation objectives.

5.2.1 Context

TraduMOOCv2 is the second version of a MOOC about translation from English to Spanish in the business and economical fields offered by the University of Valladolid (see Section 3.4). The main instructor of the MOOC (also responsible for the course design) had previous experience with MOOCs and gamification, having launched the previous run of the MOOC (TraduMOOCv1, see Section 3.3). Therefore, we considered her as a good informant for a formative evaluation, helping us understand the current support of GamiTool to the life-cycle of a gamified MOOC, exploring practitioners' needs, and identifying potential tool improvements. The instructor is a university teacher associated to the "Translation and Interpretation" Faculty at Universidad de Valladolid (Spain) with 15 and 6 years of teaching experience in blended and online university education respectively.

At this period, GamiTool prototype was in a preliminary version (see *Cycle 1* in Fig. 1.2). It was a functional prototype ,but it did not implement some of the features that were finally added to the system (see Section 4.3). Among the main limitations of the prototype, we can highlight the absence of the learning design automatic importation feature, the gamification design automatic deployment feature, and restrictions in the configuration of gamification conditions in third-party tools. Additionally, GamiTool-DM implemented a limited number of *ResourceTypes* (C.1.0 to C.1.9 in Appendix. C), *ActionTypes* (C.2.1 to C.2.27), *RuleTypes* (C.3.1 to C.3.6) and *PrivilegeTypes* (C.4.1 to C.4.12).

5.2.2 Evaluation Design

In this evaluation, we followed an anticipatory data reduction process [185], so that the general research question was subdivided into two topics (see Fig. 5.1): [T1] GamiTool

support regarding its design expressiveness, and [T2] GamiTool support regarding the affordable design, instantiation and management. Moreover, as mentioned before, this formative evaluation helped us identify potential tool refinements regarding both topics. In this context, the data reduction process was chosen to better address the specific problems that were to be addressed and their alignment with the data gathering techniques as depicted in Figure 5.2.

The evaluation was organized in three happenings. The first happening (*H1:Co-design Session*) consisted of a co-design session in which the main instructor and three researchers worked together to come up with a gamification design for the MOOC. Some days before, the instructor was requested to create a gamification design of her course including course privileges. This preliminary step was made without any tool support, to avoid influencing the instructor with the options provided with GamiTool. The final gamification design was meant to know the extent to which GamiTool supported the computer-interpretable gamification decisions made by the instructor. While the leading researcher (author of this dissertation) guided the session and solved emerging questions, the other two researchers acted as observers, taking notes about the interactions and reactions of the instructor (see *[H1:Obs]* in Fig. 5.2).

During this phase, the gamification concepts (*e.g.*, condition, association, course privilege) were introduced to the instructor without giving explicit examples to avoid biasing her in the co-design session. The instructor was then requested to describe the gamification design she had created in advance with the gamification concepts we had introduced in this phase. The conceptualized gamification design was meant to understand the extent to which GamiTool-DM was able to represent the gamfication decisions of the MOOC instructor.

Later, the instructor, with the guidance of the leading researcher, digitally represented the conceived gamification design using GamiTool. During this process, the instructor was requested to modify the gamified design in case her decisions could not be represented with GamiTool, or in case GamiTool provided her with new useful ideas (*e.g.*, conditions not considered before) *[H1:Art]*. Her interaction with the GamiTool interface, was meant to provide insights about how costly is the design and instantiation of a MOOC gamified design by its main instructor. At the end of the co-design session, the participant was asked to fill out a questionnaire about the design expressiveness and practitioners' affordability of GamiTool *[H1:Quest]*. Content validity of the questionnaire was tested after several iterations with three TEL-research experts from GSIC-EMIC group.

The second happening (*H2:MOOC Enactment*) was the enactment of the gamified MOOC, involving the management by the course instructors of the reward-based strategies supported by GamiTool. During this happening, the participant was responsible for monitoring and watching over the student interactions with the gamification elements through the GamiTool graphical interface embedded in the course (see Fig. D.6). Additionally, the main instructor was also responsible for applying the manual course privileges such as the instructor evaluation of students' submission or the creation of video-conferences with students. Despite these two privileges were not automatically applied, GamiTool provided support to perform them (*e.g.*, a list with the rewarded students and the link with the student submissions that had to be evaluated by the instructor). This real experience managing reward-based strategies in a MOOC help us understand whether

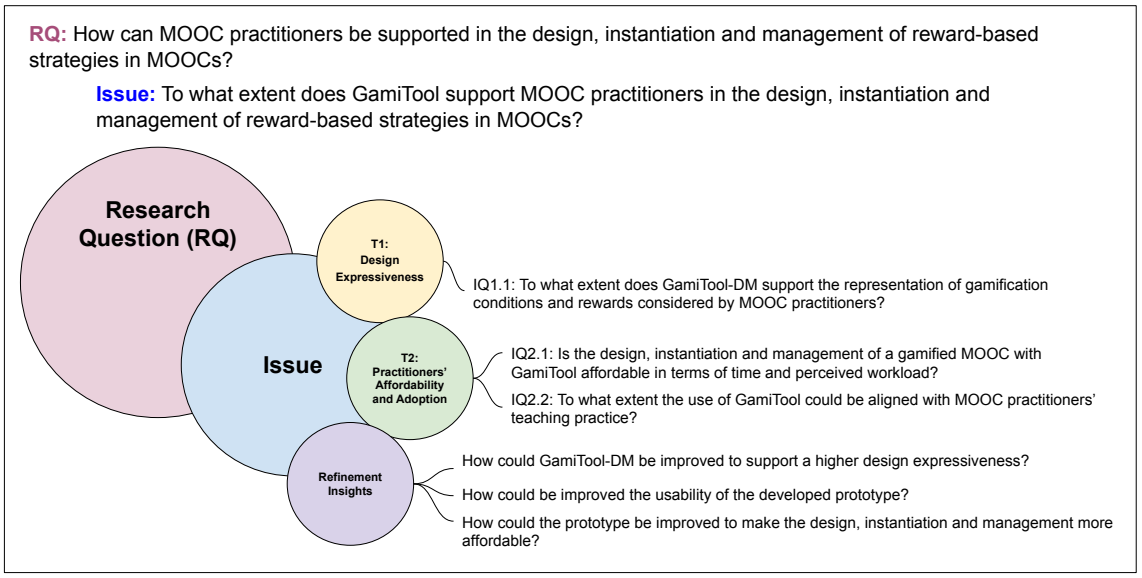


Figure 5.1: Anticipated research design including the research question, the research topics and the informative questions guiding the first evaluation.

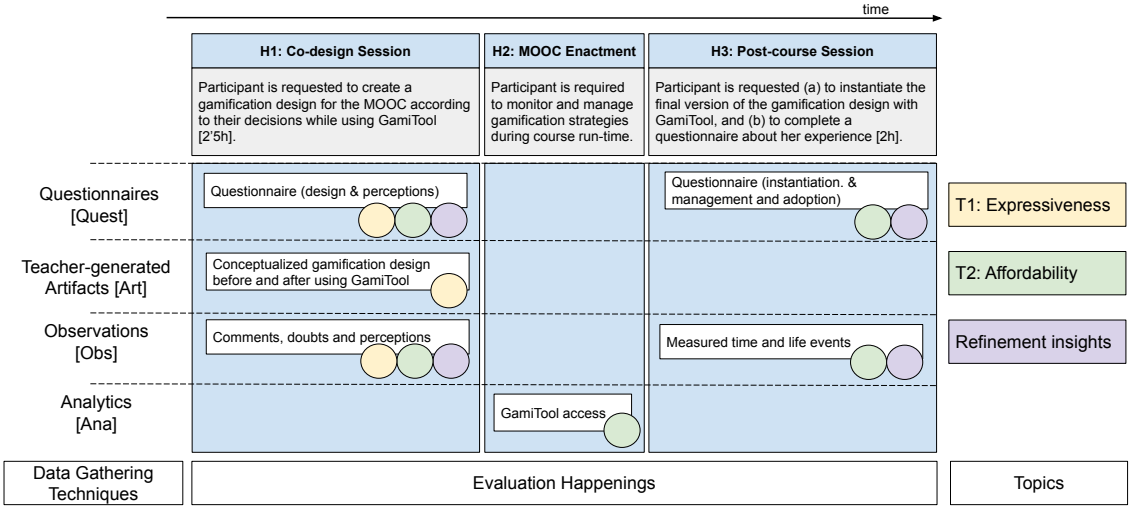


Figure 5.2: Evaluation happenings and data gathering techniques used during the first evaluation.

Figure 5.3: GSIC-EMIC meeting room during the first happening of the evaluation.

GamiTool supported the instructors in an affordable way during the enactment of the course *[H2:Ana]*.

During the third happening *[H3:Post-course session]*, the participant and the researcher met again with two main purposes. The first purpose consisted on letting the instructor use GamiTool to digitally represent and instantiate the final gamification design, to understand the effort and time that the practitioner would need in a real situation[2] *[H3:Obs]*. The second task was the fulfillment of a questionnaire, regarding practitioner's perceptions and experience about the previous task and about the gamification management during course run-time *[H3:Quest]*. Again, the content validity of the questionnaire was provided by the same three TEL-research experts that validated the questionnaire administered in the first happening. Both the co-design and post-course sessions were held in the GSIC-EMIC meeting room at Universidad de Valladolid (Spain) as shown in Figure 5.3.

5.2.3 Results: Design Expressiveness

Table 5.1 presents a summary of the gamification design conceptualized by the instructor before the co-design session. GamiTool-DM was able to explicitly represent 3 out of 4

[2]It is worth to mention that the gamification design implemented in the course involved three experimental conditions: badges, course privileges and no-gamification as described in Section 3.4. For this reason, the digital instantiation of the gamification was carried out by the leading researcher in the original MOOC platform. The participant was requested to design and instantiate the design involving course privileges once the course was finished, thus simulating the steps she would have been carried out in a real situation.

Assoc.	Condition	Reward
#1A	Watch all 'summary videos' located at the end of each module (M1-5).	Provide additional learning materials associated to course topic.
#2A	Participate in optional activities: course glossary (M1) and text translation (M3).	1-hour video-conference with course instructors.
#3A	Participate in optional activities: text search (M2) and text translation (M4).	Skip the content quiz (M6).
#4A	Participate in discussion forums from modules incorporating quizzes (M1,M2,M6).	Get 2 extra points in the score obtained in the first attempt of quizzes (M1,M2,M6).

Table 5.1: Conditions and rewards conceptualized by the instructor before the co-design session. Green color indicates those conditions and rewards that could be supported by GamiTool-DM.

Assoc.	Condition	Reward
#1B	Visit the pages containing the 'summary videos' located at the end of modules M1-2.	Extend 2 days the due date of compulsory assignment (M2).
#2B	Edit the course glossary (M1) and submit the optional text translation (M3).	Unlock the page containing the video-conference tool to discuss course contents and doubts with the instructors (M5).
#3B	Submit the optional activities: text search (M2) and text translation (M4).	Skip the content quiz (M6).
#4B	Receive at least 10 likes in discussion forums (M0-5).	Get 1 extra attempt in quiz (M1).

Table 5.2: Conditions and rewards configured by the instructor during the co-design session using GamiTool. Green color indicates those conditions and rewards replaced from the original design, after using GamiTool.

conditions (*#2, #3, #4*), and the 4 rewards *[H1:Art]*. Only condition #1 could not be represented with GamiTool-DM due to the lack of elements and parameters to represent *video resources* over which conditions can be configured. Therefore, this information was used to improve it, supporting videos as resource types, and adding action conditions associated to such videos (*e.g.*, watch a specific % of the content).

Afterwards, while using GamiTool, the instructor realized about the previous design constraint. The aforementioned condition was then replaced by a similar one supported by GamiTool: *visiting the pages containing the 'summary videos'* (#1 at Table 5.2). Despite this fact, the participant answered that she *strongly disagreed* to the statement *GamiTool constrained the gamification design that previously conceptualized* of the final questionnaire (see Q1DE in Table 5.3) *[H1:Quest]*. Therefore, it is likely that the alternative solution provided by GamiTool-DM satisfied the condition initially conceived by the participant. Nevertheless, we updated GamiTool-DM including *video* as a new resource type (see *C.1.10* in Appendix C.1), *watch* as new action type (see *C.2.28* in Appendix C.2), and *at least a % of* as a new rule type (see *C.3.7* in Appendix C.3).

A second condition that could not be represented referred to an external resource: the course glossary (#2 at Table 5.2) *[H1:Art]*. By that time, GamiTool was not supporting the configuration of conditions in *external tools* resources though the graphical user interface. Accordingly, the instructor considered the implementation of the glossary as an editable content page, in which *editing*, would be the requirement to satisfy the condition. Therefore, the condition could be represented with GamiTool but after changing the learning design of the course. Besides, during this process, the participant also considered the addition to the learning design of a new page (video-conference with course instructors) that would be unlocked once the associated condition was satisfied. Therefore, the instructor changed twice the learning design while creating the gamification design *[H1:Art]*. This fact was also supported by the *somehow agree* answer regarding the Q6DE item: *GamiTool made me reflect whether I should edit the learning design of the course*.

Additionally, while presenting and using GamiTool, the instructor realized about potential conditions and privileges that she did not consider before that could be useful for her gamification and learning purposes: *"Woo, All these [privileges] are good ideas that I didn't consider" [H1:Obs]*. The participant stated the usefulness of such proposals and replaced one condition and two course privileges from the conceptualized gamification design as presented in green color at Table 5.2. It is worth mentioning that once the gamification design was finished, the participant explicitly mentioned that *"If these privileges were not automatically applied, they would turn me crazy [during course run-time]" [H1:Obs]*, thus supporting the importance of the automated issuing process. These observations and the changes performed in the conceptualized gamified design support the *strongly agree* answer in Q2DE item: *GamiTool suggested conditions and rewards that I did not consider before and which could be useful to attain the expected gamification purposes [H3:Quest]*. Further work was needed to understand whether the support received during gamification design is particular for this participant, or it is extensible to experienced and/or non-experienced users.

The instructor decided to configure four associations for the whole course expecting to last 8 weeks. However, during the gamification design with GamiTool, she showed certain concerns regarding the most appropriate number of associations: *"I don't know*

how many [associations] configure in order to not have too few, or too many, and to not overwhelm the students" [H1:Obs]. Considering that the participant did not arise this issue during the conceptualization of the design, this comment suggests that GamiTool also helped reflect about the gamification design (although it was not explicitly designed with that purpose).

The answers provided in the questionnaire of the co-design session *[H1:Quest]* also showed that GamiTool (Q1DE5) provided useful information during the design and deployment of gamification; (Q1DE7) helped to better understand the configured design and its relation with the learning course goals; and (Q1DE8) enabled the alignment of the course pedagogical approaches (*e.g.*, collaborative learning at the course glossary) with the gamified activities. Furthermore, these positive results were also confirmed in the answers provided in the post-course questionnaire *[H2:Quest]*.

5.2.4 Results: Practitioners' Affordability and Adoption

The computer-interpretable representation and instantiation of the conceptualized design (4 associations, see Table 5.2) during the co-design session took 34 minutes to the instructor *[H1:Obs]*. However, it is worth mentioning that apart from the support received by the researcher during the digital representation process, the participant received a 15- and 39-minute introduction to gamification in learning environments and to GamiTool respectively. The overall time and workload devoted to design and instantiate the conceptualized gamification with GamiTool was perceived by the participant as affordable (Q1PA1 and Q1PA2 in Table 5.3) *[H1:Quest]*. Additionally, the participant *strongly agreed* that GamiTool was easy to use for the design and instantiation of the conceptualized gamification design (Q1PA3) *[H1:Quest]*.

During the post-course session, the same experiment was repeated to understand the time and cognitive cost of implementing the final gamification design (8 associations involving course privileges, see group REDEEM in Fig. 3.17). After 15 minutes of introduction to GamiTool, the participant completed the task in 59 minutes, only receiving support from the researcher under request *[H3:Obs]*. The overall time and workload devoted to design and deploy the final gamification with GamiTool was again perceived by the participant as affordable (Q2PA1 and Q2PA2 in Table 5.3). Additionally, the participant also *strongly agreed* that GamiTool was easy to use for the design and deployment of the conceptualized gamification design (Q2PA3).

Regarding the affordability of managing gamification with GamiTool during course enactment, the participant accessed 17 times (2,12 times per week) to the gamification tab inserted in Canvas (5 times more by the teacher assistant) *[H2:Ana]*. According to the participant, GamiTool Canvas interface showed useful information to understand the state of the gamification throughout the course (Q2PA5) *[H3:Quest]*. The participant argued that the information provided by GamiTool showed during course enactment was fair for its purpose. Nonetheless, the instructor also stated that *"sometimes I forgot that gamification was inserted in the course" [H3:Quest]*. There can be twofold interpretation to that statement: (a) the automatic management of rewards and the lack of issues related to gamification made the management of rewards more affordable, and/or (b) the lack of notifications made the instructor forget to watch over the course gamification, suggesting

Assoc.	Questionnaire item	Answer
Q1DE1	GamiTool constrained the gamification design that I previously conceptualized.	1. Strongly Disagree
Q1DE2	GamiTool suggested conditions and rewards that I did not consider before and which could be useful to attain the expected gamification purposes.	6. Strongly Agree
Q1DE3	GamiTool enables the design and deployment of gamified activities performed in tools frequently used in MOOCs (*e.g.*, forums, quizzes).	6. Strongly Agree
Q1DE4	GamiTool enables the creation of gamified learning designs aligning the learning goals with the gamification purposes (*e.g.*, motivate students).	6. Strongly Agree
Q1DE5	The information that GamiTool provided during the design and deployment of the gamification has been useful	6. Strongly Agree
Q1DE6	GamiTool made me reflect whether I should edit the learning design of the course.	4. Somehow Agree
Q1DE7	GamiTool enabled understanding clearer which activities are associated to conditions and rewards, and how they can affect to the learning goals as compared with the direct implementation in the MOOC platform.	6. Strongly Agree
Q1DE8	GamiTool enabled the design of MOOC gamified activities under the pedagogical approaches that I wanted to apply.	6. Strongly Agree
Q1PA1	I think the time time devoted to design and deploy the gamification is affordable.	6. Strongly Agree
Q1PA2	I think the cognitive workload devoted to design and deploy the gamification is affordable.	6. Strongly Agree
Q1PA3	I think GamiTool is easy to use regarding the design and deployment of gamified MOOCs involving course privileges for MOOC practitioners.	6. Strongly Agree
Q1PA4	I would use GamiTool to gamify with traditional rewards (*e.g.*, points, medals) other MOOCs in which I am involved as practitioner.	5. Agree
Q1PA5	I would use GamiTool to gamify with course privileges (*e.g.*, extra attempts, due date extension) other MOOCs in which I am involved as practitioner.	6. Strongly Agree
Q1PA6	GamiTool enabled me to design and deploy MOOC gamified activities similar to the ones I would implement in my traditional classes.	5. Agree

Table 5.3: Questionnaire items and participant answers regarding GamiTool design expressiveness, affordability and adoption during the co-design session.

Assoc.	Questionnaire item	Answer
Q2DE1	GamiTool enables the creation of gamified learning designs aligning the learning goals with the gamification purposes (*e.g.*, motivate students).	5. Agree
Q2DE2	The information that GamiTool provided during the design and deployment of the gamification has been useful	5. Agree
Q2DE3	GamiTool enabled the design of MOOC gamified activities under the pedagogical approaches that I wanted to apply.	6. Strongly Agree
Q2PA1	I think the time time devoted to design and deploy the gamification is affordable.	6. Strongly Agree
Q2PA2	I think the cognitive workload devoted to design and deploy the gamification is affordable.	6. Strongly Agree
Q2PA3	I think GamiTool is easy to use regarding the design and deployment of gamified MOOCs involving course privileges for MOOC practitioners.	6. Strongly Agree
Q2PA4	GamiTool enabled solving the gamification-related problems I faced during course enactment.	Don't know / No answer
Q2PA5	GamiTool Canvas interface showed useful information to understand the state of the course rewards.	5. Agree
Q2PA6	The cognitive and time workload devoted to make changes in the gamification design while the course was running was high.	Don't know / No answer
Q2PA7	I think the time time devoted to manage the gamification while the course was running is affordable.	5. Agree
Q2PA8	I think the cognitive workload devoted to manage the gamification while the course was running is affordable.	5. Agree

Table 5.4: Questionnaire items and participant answers regarding GamiTool design expressiveness, affordability and adoption during the post-course session.

Phase	Introduction to gamification	Introduction to GamiTool	Digital Representation & Instantiation with GamiTool
[H1] Co-design session	15min	39min	34min* (4 associations)
[H3] Post-course session	5min	10min	59min (8 associations)

Table 5.5: Summary of the time cost (minutes) employed for the design and deployment of the gamified MOOC with GamiTool. *Time with the guidance of the researcher.

the need of studying how to make teachers aware of the gamification mechanism without burdening them.

Moreover, the teacher was able to change the gamification design on-the-fly, in response to her understanding of the course current state. More concretely, she redesigned the Text Provider! condition to *receive 5 likes* instead *receive 10 likes* due to the limited number of active students participating in this optional task. While completing the post-course questionnaire, the participant expressed that she did not remember how costly was performing such change (Q2PA4, Q2PA6) *[H3:Quest]*.

Practitioner's eventual adoption of GamiTool to orchestrate reward-based strategies in MOOC environments was evaluated in the co-design questionnaire *[H1:Quest]*. The answers provided by the participant suggest that GamiTool could be potentially adopted to gamify MOOCs with traditional rewards (Q1PA4) and with course privileges (Q1PA5). Furthermore, the participant expressed her interest on using GamiTool for her regular teaching practice (Q1PA6), stating whether *"it [GamiTool] could be used for Moodle [VLE in which she regularly teaches university teaching]?"*. Further research involving more practitioners from different institutions and with different backgrounds is needed to better explore this aspect of the evaluation.

5.2.5 Insights for Tool Refinement

Observations and a think-aloud protocol during the co-design and post-course sessions together with questionnaires' answers provided useful insights for future refinements supporting GamiTool design expressiveness, usability and affordability. Regarding the design expressiveness of GamiTool, three important suggestions of improvement were identified: (1) the addition of the resource type *video* and the potential associated actions and rules than can be used as conditions for earning rewards (*e.g.*, watch 50% of the video); (2) enabling the user to configure external tool instances (*e.g.*, Google Spreadsheets, Zoom) from the GamiTool user interface, thus supporting their affordable gamification; and (3) the clarification of the concept *gamification engine* (previous name given to *gamification association*) since the instructor presented doubts during the co-design session about its meaning.

Regarding the usability of the GamiTool interface, we can highlight the following improvements noted by the participant: (1) add notifications of successful creation, edition and removal of associations, conditions and rewards; (2) add names and or descriptions to the learning design resources including the modules containing them; (3) add information about the data types supported when configuring the gamification learning design (*e.g.*, conditions, course privileges); (4) add notifications when compulsory data fields are forgotten; and, (5) reverse the order in which the gamification associations appear in the gamification page (the last configured association should appear first).

Regarding the affordability and adoption of GamiTool, the participant complained about the manual representation of the learning design in GamiTool (this version did not incorporate automatic mechanisms to import learning designs from the MOOC platforms). This fact made us reflect about the incorporation of MOOC adapters to import learning designs from existing MOOC platforms into GamiTool-ARCH, thus reducing the time needed to gamify a course. Also, as pointed out in the previous subsection, noti-

fying practitioners about important actions within GamiTool during course run-time (*e.g.*, pending manual privileges need to be applied) can help them save time.

All these potential insights were taken into account in the next version of GamiTool, which was again evaluated by MOOC practitioners and/or gamification designers (see Section 5.3). Both, the refinement of GamiTool and the following evaluation, were framed into the next cycle of the SDRM methodology (see *Cycle 2* in Fig. 1.2).

5.2.6 Discussion

This first evaluation provided initial evidence about how GamiTool supports the affordable design, implementation and management of MOOCs involving reward-based strategies. The participant of the evaluation represented her conceptualized gamification design with GamiTool with minor changes. Additionally, the pool of conditions and privileges supported by GamiTool made the participant reflect about her conceptualized gamification design, replacing some of the design decisions she took before using it. Further studies would be needed to understand whether this benefit was exceptional for this practitioner, for non-experimented practitioners, or for most MOOC practitioners using reward-based strategies.

The time employed during the implementation of gamification, and the answers provided in the questionnaire of both sessions (co-design and post-course), provided first insights confirming the benefits of using GamiTool for the affordable (time and workload) orchestration of reward-based strategies in MOOCs. However, this evaluation only involved one practitioner, who pointed out certain usability potential refinements (*e.g.*, add notifications and further information), and who needed the support of the researcher at certain moments of the gamified MOOC life-cycle. Accordingly, the next evaluation iteration should address the major limitations of this study including more participants with different previous MOOC and gamification experience, working independently with a new version of the tool, and applying the refinements emerged from this study.

5.3 Second Evaluation

The main purpose of the second evaluation was to understand the extent to which GamiTool supports the computer-interpretable representation (*i.e.*, design expressiveness), and the affordable orchestration of reward-based strategies in MOOC environments with a broader sample, and without the support of researchers. Therefore, a similar evaluation design than the previous study was followed to help answer the following research question: *How can MOOC practitioners be supported in the design, instantiation and management of reward-based straegies in MOOCs?*. However, differently from the previous evaluation, and due to the limitations to find practitioners participating in MOOCs during the upcoming months (in the platforms for which GamiTool adapters were developed), the evaluation did not address the analysis of how affordable is the gamification management with GamiTool during course run-time.

5.3.1 Research Design

During the evaluation design, an anticipated data reduction process was followed to help answer the RQ attending to this dissertation's goals as identified in the previous chapters [185]. Accordingly, the RQ was specified into an issue, and this issue was subdivided into two topics of study: design expressiveness and practitioners' affordability and adoption, being both of them further divided into several informative questions. Additionally, similarly to the previous evaluation, and as part of the methodological process followed, insights for tool enhancement were collected for future refinement (see Fig. 5.4).

A user experience evaluation [5] was performed to understand the extent to which GamiTool supports the purposes for which it was developed. Figure 5.5 illustrates the evaluation process which was divided into four sequential happenings or evaluation events, which involved three different data-gathering techniques supporting evidence triangulation. The evaluation tasks that participants had to fulfill were designed to be completed online within two hours to reach a higher number of available worldwide participants without physical presence.

The first happening (H1: Previous steps) involved the completion of a questionnaire about participants' demographic and previous experience information. This information aimed at profiling the participants of this study and to understand whether some results can be attributed to the previous experience of evaluation participants.

In the second happening (H2: Own-design), participants were introduced to the evaluation topic, giving special emphasis to MOOCs, reward-based strategies and course privileges. To this end, participants were invited to read page 4 of the given worksheet (see Appendix E). During this happening, participants were also requested to create their own gamification design over a given MOOC, incorporating multiple resource types such as discussion forums, content pages, self-contained videos, submissions, quizzes, peer reviews, etc. Information about the task and about the given MOOC was presented in pages 5-7 of the given worksheet (see Appendix E). The main purpose of this happening was to collect rewards, conditions and associations that MOOC practitioners and gamification designers would use in their MOOC teaching practice to understand the extend to which GamiTool-DM could represent such gamified MOOCs. The designs provided by the participants were analyzed by the leading researcher to assess whether they could be modeled with GamiTool-DM. They were classified into *supported*, *partly-supported*, *supported with minor changes* or *non-supported*.

During the third happening (H3: Representation & Instantiation), practitioners were asked to digitally represent, instantiate and preview a given gamified MOOC with GamiTool (see pages 8-12 of the given worksheet at Appendix E). The instanced gamification and the time employed during the whole process can help understand the usability and affordability of using GamiTool in a potential real situation.

Finally, the fourth happening (H4: Post steps) involved a set of questionnaires regarding participants' experience with GamiTool including the perceived usability, the perceived workload and some personal perceptions regarding GamiTool and reward-based strategies (see pages 13-14 and 16-17 of the given worksheet at Appendix E). After exploring several frequently-used questionnaires for measuring perceived usability of technological systems such as the Computer System Usability Quest (CSUQ) [161], the Questionnaire for User Interface Satisfaction (QUIS) [46], the Usefulness, Satisfaction and

Ease-of-Use (USE) [173], and the Software Usability Measurement Inventory (SUMI) [146], the System Usability Scale (SUS) [36] was selected as the most appropriate instrument for this evaluation. SUS is a widely used standardized questionnaire composed of 10 alternating positive and negative statements scored on a 5-point scale of strength of agreement, providing a final score of perceived usability which can be easily compared with previous usability studies using this scale [24, 162]. The length of the survey (keeping the whole evaluation short), and the high number of technological systems evaluated with this instrument [24, 162], made the SUS questionnaire a suitable tool to measure and compare the perceived usability of GamiTool.

Additionally, the Net Promoter Score (NPS) item [231], frequently used to measure user loyalty and adoption, was added after the SUS questionnaire. The popularity of this metric and the single likelihood-to-recommend item keeping the evaluation short, made it suitable for measuring the potentiality of this tool for adoption.

Similarly, after exploring questionnaires for measuring the perceived workload of a task such as the Subjective Workload Assessment Technique (SWAT) [232], the NASA Task Load Index (NASA-TLX)[3] was selected as the most appropriate for this evaluation. The NASA-TLX consists of six sub-scales representing six different variables (mental, physical an temporal demands, frustration, effort and performance) that participants have to rate in a 21-point scale, and whose combination is likely to represent the perceived workload of a task [115]. Keeping the same considerations for selecting the SUS questionnaire, the length of the survey and the high number of studies involving technological systems evaluated with this instrument [115], made the NASA-TLX a suitable instrument to measure the perceived workload of designing and instantiating a MOOC gamification design with GamiTool. The NASA-TLX instrument has been previously used in the educational research area to measure the perceived workload of performing a task with a given tool (*e.g.*, [6, 91]). With the purpose of keeping the evaluation within the 2-hour estimated limit, we used the raw version of the NASA instrument (Raw TLX, RTLX), since the contribution of the sub-scales weighting process for the final score is unclear [115].

For every questionnaire, open-ended boxes for additional comments and clarifications were included (1) to help understand the reasons for the scores given to the previous questionnaires, and (2) to collect participants' opinions for future tool enhancements. An evaluation guide including the evaluation tasks and evaluation instruments was developed (see Appendix E) to homogenize and guide participants throughout the whole process. The evaluation guide was created with Adobe Acrobat Pro DC[4] to allow the digital completion of the evaluation questionnaires in the same document as the evaluation guide. Participants were requested to online complete the evaluation questionnaires, facilitating their processing. Participants' answers were exported into a *.csv* file and processed with the RStudio[5] software to perform the statistical analyses presented in this section.

[3]NASA Ames Research Center. Nasa Task Load Index (TLX) v.1.0, Paper and Pencil Package. Retrieved from: *https://humansystems.arc.nasa.gov/groups/TLX/downloads/TLX_pappen_manual.pdf*, last access: September, 2020.

[4]Adobe Acrobat: *https://acrobat.adobe.com/es/es/acrobat/acrobat-pro.html*, last access: September, 2020.

[5]RStudio: *https://rstudio.com/*, last access: September, 2020.

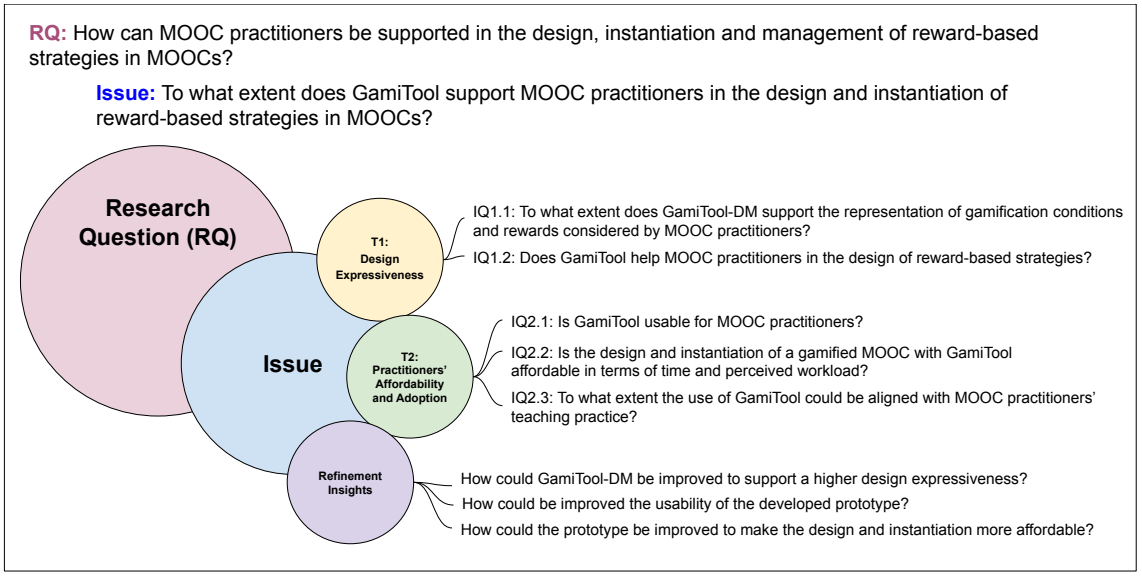


Figure 5.4: Anticipated research design including the research question, the research topics and the informative questions guiding the second evaluation.

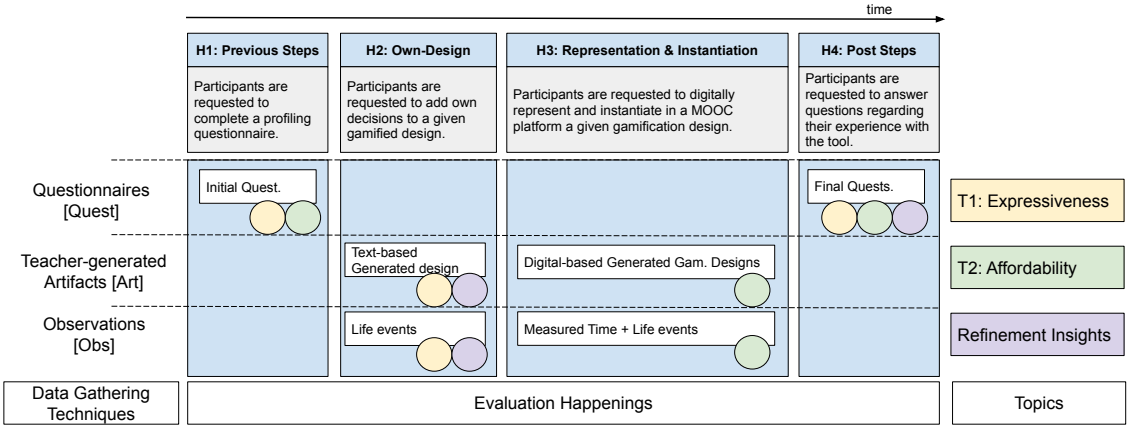


Figure 5.5: Evaluation happenings and data gathering techniques used during the second evaluation.

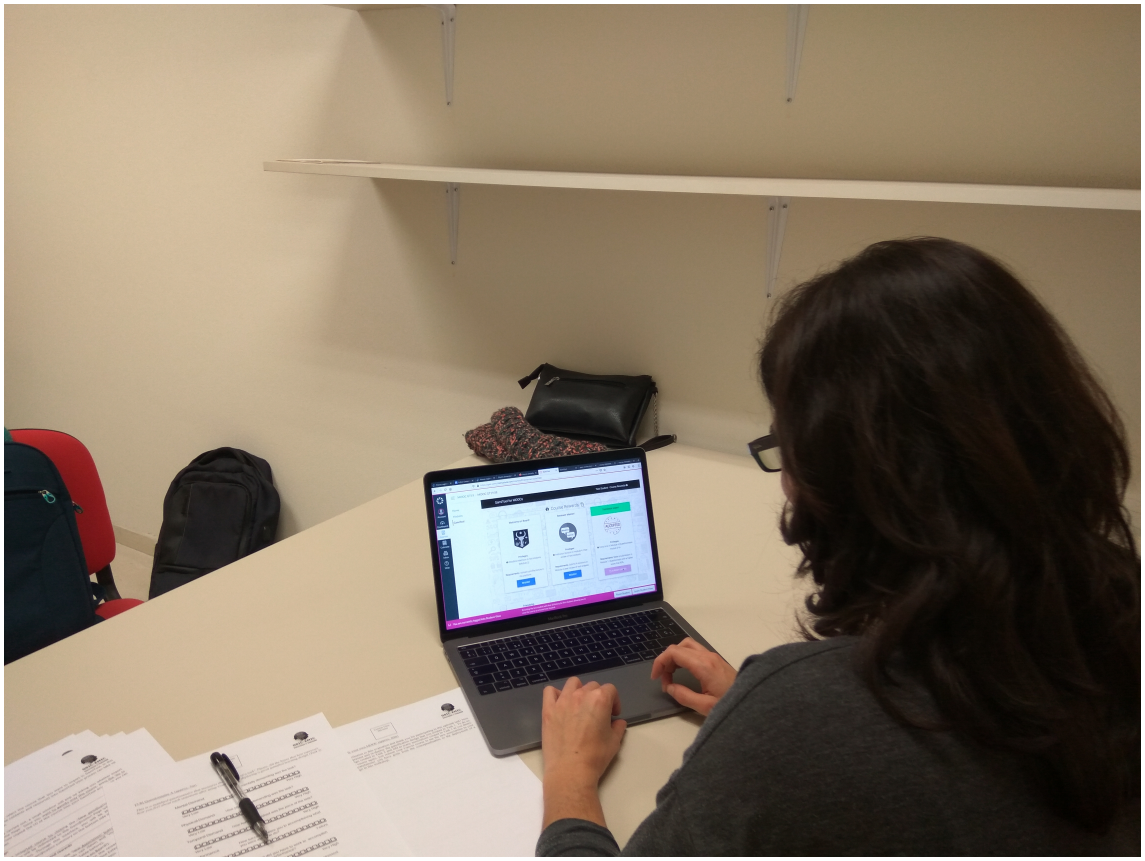


Figure 5.6: MOOC practitioner interacting with GamiTool during the evaluation.

5.3.2 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 (participants and size) that matches with the specific purposes of the research [94]. The purposive sampling was selected to address participants with previous experience as MOOC practitioner and/or gamification designer. According to Albert & Tullis (2013) [5], traditional user experience evaluations in which a moderator gives tasks to perform and asks questions, typically involve from 5 to 50 participants, observing the most significant usability findings with the first six participants. Additionally, according to Lewis (2018) [162], evaluations involving SUS questionnaire require a minimum number of five participants per item to ensure its *construct validity* (*i.e.*, the degree to which inferences can legitimately be made from questionnaire items). Furthermore, although participants' geographical location is unlikely to have an impact on usability information [5], participants from different countries and institutions will help us understand the perceptions of participants that follow different MOOC procedures and use different MOOC platforms.

Attending to the previous requirements, 23 potential worldwide participants were contacted via email, out of which 19 agreed to participate in the study. Results reported in the initial questionnaire showed that the participants of this evaluation were from 10 different

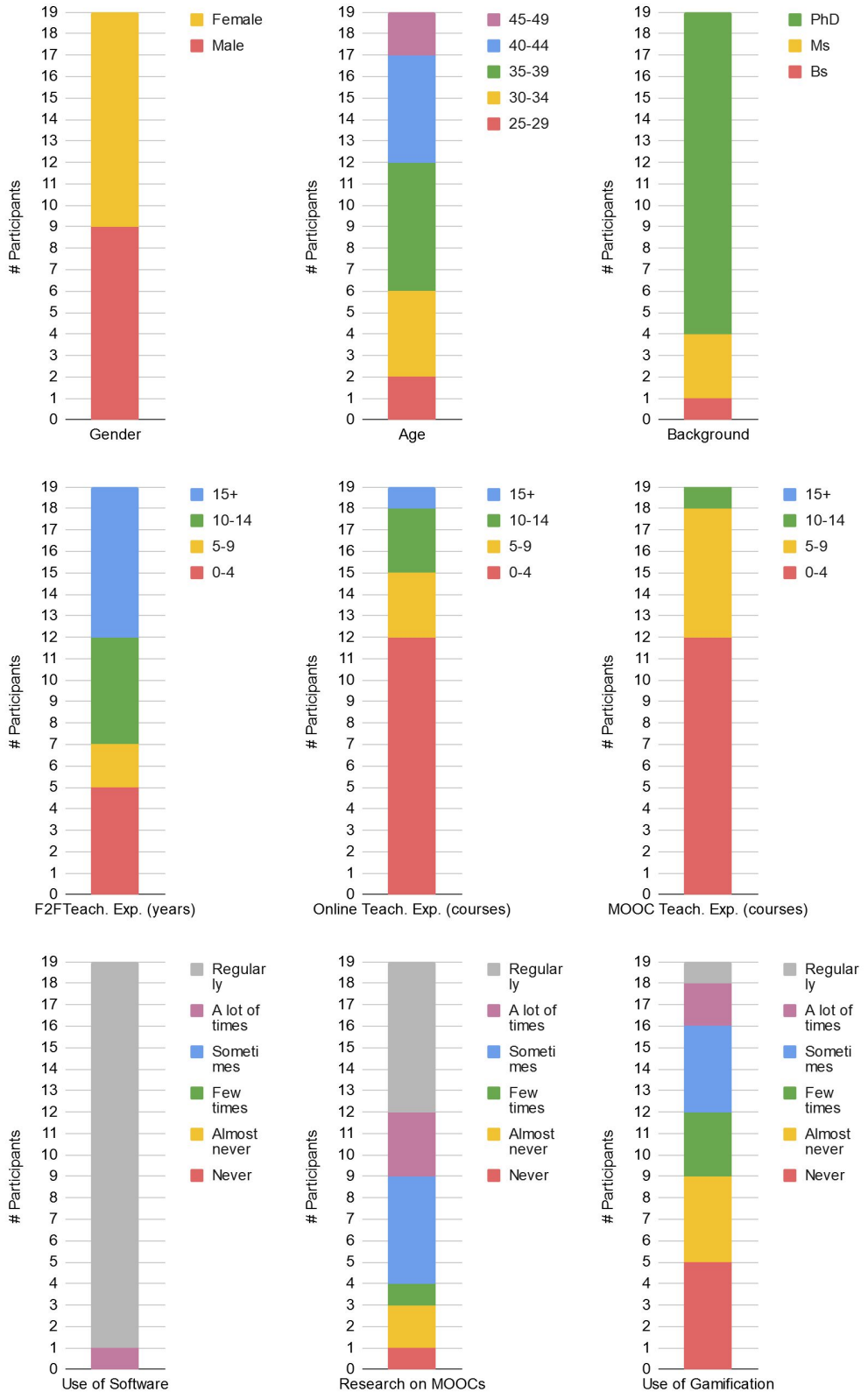


Figure 5.7: Demographic and previous experience participants' information.

educational institutions located in 6 different countries: USA (1), UK (2), Germany (1), France (1), Norway (1) and Spain (13). Further information about evaluation participants is presented in Figure 5.7.

5.3.3 Results: Design Expressiveness

During [H2: Own-design], participants were requested to create their own gamification design over a given MOOC. They should design at least 3 gamification associations (apart from the given example) including their name, purpose, condition and reward. A total number of 71 gamification associations were collected from participants' answers (3 associations x 6 participants + 4x12 + 5x1). Both gamification conditions and rewards were analyzed to understand the extent to which GamiTool-DM supports their representation.

Gamification Conditions

Participants' explicit conditions involved the four different types of conditions considered during the feature analysis and GamiTool-DM proposal:

1. Conditions based on previous earned rewards: *e.g.*, *"For each added term [glossary activity], students will receive one point, every three points, students will receive a course privilege" [H2:Art:Part#6]*[6].

2. Conditions involving group activities: *e.g.*, *"Active participation in group work of Module 3" [H2:Art:Part#17]*.

3. Conditions based on individual student actions performed within frequent MOOC activities: *e.g.*, *"Post 2 comments in the forum" [H2:Art:Part#4]*, *"Complete the final quiz of the course" [H2:Art:Part#13]*, *"Review 2 submissions" [H2:Art:Part#17]*; with fine-grain of detail, *e.g.*, *"Submit [..] by the end of Module 3" [H2:Art:Part#19]*, *"[..] complete all graded activities with an 80% or more [..]" [H2:Art:Part#3]*; and, in external tools, *e.g.*, *"Introduce yourself in the Twitter, Facebook and Social Forum" [H2:Art:Part#10]*, *"Post the best meme about the course in the Facebook page [..]" [H2:Art:Part#12]*.

4. Conditions based on peer approval: *e.g.*, *"If you more get more than 10 likes from your translation, you'll get the reward" [H2:Art:Part#18]*, although none considered group peer approval, as conceived in the feature analysis.

Additionally, the answers provided in the final questionnaire [H4:Quest], confirmed that GamiTool (implementing GamiTool-DM) enables the representation of gamified activities performed in frequent MOOC tools [DEQ2] and with a fine-grain of detail [DEQ3] (see Table 5.7). All the additional comments provided to [DEQ2] agreed on the broad coverage of MOOC frequent 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]*. Similarly, most comments associated to

[6]For a better comprehension, data evidence was tagged with the following code: [Happening:Source:Participant].

Tag	Questionnaire item
[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.
[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).
[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.
[DEQ4]	I think Redeemable Rewards (e.g., extend a quiz deadline) can be more engaging than Traditional Rewards (*e.g.*, badge) in MOOC environments.

Table 5.6: Final questionnaire items.

Tag	Min.	Median	Mean	Max.	NA's
[DEQ1]	1.00	5.00	4.29	5.00	1
[DEQ2]	4.00	5.00	4.87	5.00	2
[DEQ3]	4.00	5.00	4.88	5.00	1
[DEQ4]	4.00	5.00	4.94	5.00	2

Table 5.7: Summary of the answers provided to the design expressiveness items in the final questionnaire (N=19).

[DEQ3] highlight the possibility of configuring conditions and rewards with a fine-grain level of detail: *"There is a lot of detail regarding the rewards. I found it [GamiTool-DM] very completed" [H4:Quest:Part#6]* or *"Lots of trigger conditions and resource types" [H4:Quest:Part#10]*. Nevertheless, despite the high score provided in [DEQ3], two participants mentioned the potential usefulness of connecting the gamification purposes with the rules and 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 all fine-grain details" [H2:Art:Part#1]*. In spite of these comments, from a general view, GamiTool-DM supports the computer-interpretable representation of conditions that practitioners would use in MOOC real scenarios.

Going into more detail, GamiTool-DM was able to represent 32 conditions (45.07%) as stated by the participants (*supported*), 28 conditions (39.44%) involving content analysis which could be implemented with GamiTool (*partly-supported*), 10 conditions (14.08%) that could be represented with minor changes (*e.g.*, the addition of parameters or pool options for action and rule types) in the data model (*supported with minor changes*), and 1 conditions (1.41%) involving content analysis 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. However, such conditions can be inter-

preted and represented in different manners quantitatively, therefore being supported by GamiTool. 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]* poses doubts about what the practitioner refers to *active participation*. 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]* and *"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 understand whether student submissions include a *term*, their name, or the word *Hello!*. Similarly, in the latter case, GamiTool cannot automatically understand 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 previous conditions were considered as "interpretable", being possible to represent them in a broader sense with GamiTool, and therefore, categorized under the *partly-supported* category.

Results also showed ten conditions that could be represented with minor changes. The minor changes involved:

- The addition of a new parameter (*ruleOperand*) in the *Action* element, enabling the definition of multiple rules for the same action. Therefore, conditions like *"student with more interactions in the forum each week" [H2:Art:Part#12]*) can be now represented with the rules: *get more interactions* and *counting these interactions each week* for the same action, *submit in discussion forums*.

- The addition of a new parameter (*conditionPercentage*) in the *GamificationAssociation* element, enabling the definition of a percentage of completion for those divisible conditions. Therefore, conditions like *"students has to watch 80% of the videos" [H2:Art:Part#5]* can be now represented as: *students have to [action] in at least, a % of the selected resources*, without specifying which specific videos have to be watched.

- The addition of two action types, including *rate* and *receive a rating*; and three rule types, including *be ranked in the highest positions of the leaderboard* (associated to quizzes, assignments, peer reviews), login *for X number of consecutive days* (platform), and *get a score lower than X* (quizzes, assignments, peer reviews).

Accordingly, these changes were applied in the next methodological cycle (*Cycle 3*), as shown in Figure 4.5, Appendix C.2 and Appendix C.3.

Finally, one condition was identified as non-supported: *"in the term extraction activity, groups must select 20 terms including at least one different term provided by each*

group member in the individual stage" [H2:Art:Part#6]. This condition would require content analysis to understand whether the submission of one students is similar to the submission of another students in the same group. While groups are supported by GamiTool, the representation of conditions involving the comparison of student submissions would require a major change in GamiTool-DM and GamiTool subsystems. Accordingly, this condition was categorized as non-supported.

Gamification Rewards

According to the results, GamiTool-DM was able to represent 50 rewards (70.42%) as stated by the participants (*supported*), 5 rewards (7.04%) that can be represented with GamiTool but whose application would be different from what participants explicitly stated, *e.g*, instead of sending the unlocked documents via email, they are unlocked in the MOOC platform itself (*partly-supported*), 10 rewards (14.08%) that could be represented with minor changes (*e.g.*, the addition of course privilege types) in the data model (*supported with minor changes*), and 6 rewards (8.45%) that would need major changes in GamiTool-DM for real implementation (*non-supported*).

Participants' explicit rewards involved the four considered different types of rewards implemented in GamiTool: points, badges, levels and course privileges. Additionally, participants also described the use of four other types of rewards: medals, trophies, gold starts and *"gallifantes*[7]*"* which could be represented with the *Badge* and *Reward* elements, since they do not require any special parameter. Participants also used leaderboards associated to different types of rewards.

The most common rewards involved 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 to mention that although participants were introduced to the concept of traditional and privilege rewards during H2, most associations involved the latter type of reward. The extremely high score (minimum value = 4/5, median value = 4.94/5) provided by evaluation participants to [DEQ4] item at final questionnaire (see Table 5.7) confirms the positive perceptions toward course privileges for increasing students' engagement in MOOC environments.

Additionally, gamification designs created by participants presented ten rewards that could be represented with minor changes. After performing an analysis of such rewards, we concluded:

- The addition of a new course privilege to the pool of privilege types, *Submission reviewed by a different number of peers*: *e.g.*, *"The assignment Text Analysis will be sent to more reviewers, so the student will have extra feedback" [H2:Art:Part#11].*

- The addition of a new parameter (*rewardInCertificate*) in the *Reward* element, enabling the automatic addition of the configured reward and its description in the course certificate: *e.g.*, *"A badge is obtained [..]. This info is added to the final certificate" [H2:Art:Part#13].*

[7] *Gallifante* refers to a countable reward similar to points, from a famous Spanish TV show called *Juego de niños*, last access: September 2020.

- The addition of a new parameter (*resourceCondition*) in the *Leaderboard* element, enabling the configuration of rankings according to the number of times that the condition has been satisfied.
- The addition of a new parameter (*maxNumber*) in the *Leaderboard* element, enabling the definition of a maximum number of students listed in the configured leaderboard: *e.g.*, *"Social recognition - top 10 highlighted every week" [H2:Art:Part#3]*.
- The addition of a new parameter (*updateFrecuency*) in the *Leaderboard* element, enabling the definition of the leaderboard updating frequency including real-time, daily, weekly and monthly: *e.g.*, *"A badge is obtained: the list of student/s is announced every week [..]" [H2:Art:Part#13]*.

Accordingly, these changes were applied in the last methodological cycle (*Cycle 3*), as shown in Figure 4.5 and Appendix C.4.

Finally, six 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]*, *"Earn a Hall of Fame' gold star, where posts can also be pinned permanently" [H2:Art:Part#19]*). While such rewards can be represented with GamiTool-DM (*i.e.*, trophies, gold stars), the form of displaying such rewards within the course tools and contents is limited. In order to satisfy this requirement, we foresee two potential changes. MOOC platforms programming code should be edited to incorporate these rewards within the MOOC platform native tools, which would not be possible in non open-source platforms such as EdX, Canvas Network, Coursera, Udemy, etc. The other option is the development of open-source tools implementing course rewards (*e.g.*, discussion forums) which would be inserted in the MOOC platform, replacing the native tools. However, one of the requirements stated during the feature analysis was the use of MOOC platform native tools, thus avoiding the need of learning new tools and supporting the adoption of affordable gamification. Therefore, although these rewards might be supported by GamiTool-DM, we considered them as *non-supported* according to this previous requirement.

Additionally, three participants used privileges whose representation would involve major changes in GamiTool:

- *"A notebook filled with the student goal identified beforehand and including his information from the discussion forum" [H2:Art:Part#7]*.
- *"Term extraction goes down to 8 terms" [H2:Art:Part#10]*.
- *"Offer access to benchmarking data, my learning behaviour compared to other learners" [H2:Art:Part#17]*.

The first reward represents a course privilege very specific for the associated activity and which would involve major changes in GamiTool considering the general purpose of this tool. The second and third rewards involve unlocking resources whose content would have to be created by GamiTool automatically: *i.e.*, information previously inserted by the participant in a previous activity. While *unlocking content* is a privilege supported by GamiTool-DM, the creation of such information is not supported automatically.

Usefulness for Reflection

One outcome of the previous evaluation study was that the pool of conditions and course privileges incorporated in GamiTool suggested to the practitioner conditions and privileges that could be potentially used to promote her gamification purposes. Therefore, suggested privileges and conditions associated to the different types of resource incorporated in the MOOC may help practitioners reflect, design and re-design about the gamification of the course according to the considered gamification purposes. For instance, while using GamiTool, a gamification designer can realize about the *extending due date* privilege which can be useful during the vacation period of the course and which can motivate students to complete previous optional activities.

In order to understand whether GamiTool is useful for the purpose of helping practitioners reflect, design and re-design their gamifications, the final questionnaire incorporated the item [DEQ1] (see Table 5.6). Results (see Table 5.7) show that most participants strongly agreed (*median value = 5.00*) that GamiTool suggested conditions and rewards which they did not consider during the design period and could be useful for their purposes. In the additional comments associated to this item, participants stated this fact (*e.g., "Yes, I was thinking of exactly that when using GamiTool" [H4:Quest:Part#11]*), and argued 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 practitioners (*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 the use of gamification in educational environments, argued that *"the suggested tools are extremely useful but I saw or read them before" [H4:Quest:Part#7].*

In order to deepen into 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 previous experience, which was statistically significant ($r(18)$= -0.470, ρ= 0.049). Therefore, GamiTool is in general perceived as useful for the reflection and design of gamified MOOCs ([DEQ1] mean value = 4.29, [DEQ1] median value = 5.00). However, it is likely that the more experienced the participant is with gamification, the less useful for reflection, design and re-design GamiTool is.

Additionally, two participants mentioned that some suggested course privileges made them reflect about some configurations in the learning design (*e.g., "in order to provide extra time in a quiz, you need to know beforehand the expected time for quiz completion" [H4:Quest:Part#2]*). Therefore, the suggestion of course privileges can also help practitioners reflect about certain aspects of the learning design that would not be considered without the use of GamiTool, thus anticipating possible problems during course run-time.

5.3.4 Results: Practitioners' Affordability and Adoption

Workload

Participants' perceived workload of designing and implementing a gamified MOOC with GamiTool was measured through the RTLX questionnaire. Individual and average scores are presented in Figure 5.8 and Table 5.8. Participants' final score has been calculated as the average value provided to the six variables conforming the perceived workload of the task [115]. According to the results, the average RTLX final score is 31.57 (in a 0-100 scale, where 100 is the maximum measurable workload). 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 (including the cognitive and time load).

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 (see Fig. 5.8). Mental and temporal demand are the variables that scored higher (*i.e.*, higher workload) for most participants (see median and 3rd qu. values in Table 5.8). Additional comments provided in the final questionnaire helped to understand the reasons for such difference. Many participants referred to the initial mental demand for learning how to configure the first gamification associations with GamiTool, at the same time they were reading the evaluation guide. Once participants learned how to use the tool and how to configure the firsts gamification associations within the gamification design, such mental and time demand drastically decreased. Examples of participants' comments referring to this initial cost are:

- *"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].*

- *"There is a learning curve as in every other tool. [..] every time I had to create a new association I found it easier. The more I knew the tool and options, the easiest and faster it was for me to create new associations" [H4:Quest:Part#3].*

- *"Considering it was the first time I was using it, the overall demand was load" [H4:Quest:Part#11].*

These additional comments suggest that for the following times that participants use GamiTool, the mental and temporal demand of digitally representing and instantiating a MOOC gamification design will be much lower.

Regarding the temporal demand, the two participants that scored highest (75 and 70) complemented their answers with additional comments:

- *"Temporal demand - not due to the task but rather due to the pending tasks I have to finish after the workshop so I want to finish it sooner rather than later" [H4:Quest:Part#15].*

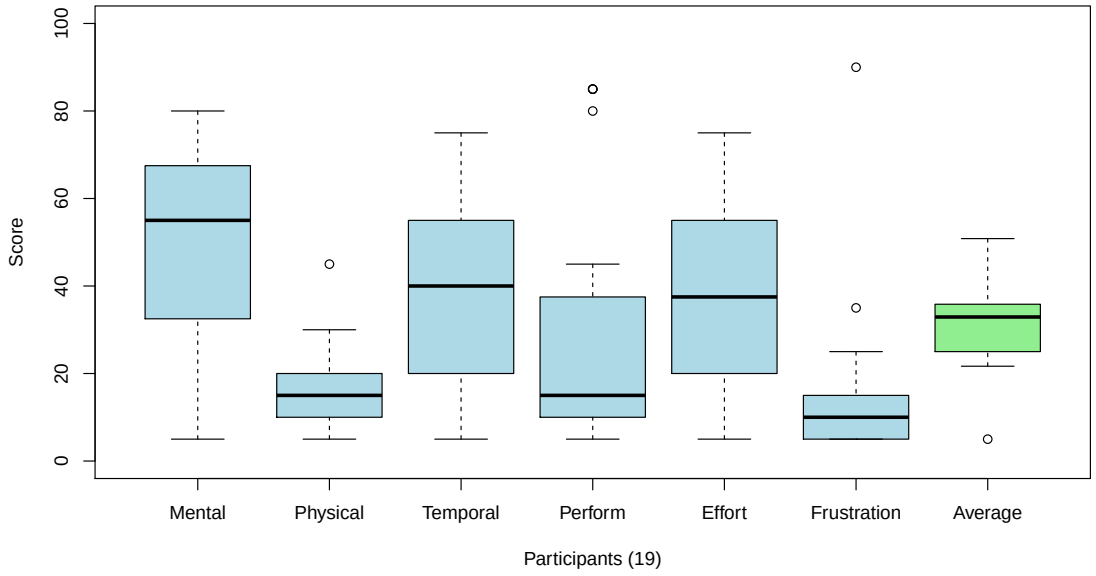


Figure 5.8: RTLX overall results.

Item	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Mental	5	32.50	55	49.47	67.50	80
Physical	5	10	15	15.79	20	45
Temporal	5	20	40	37.63	55	75
Perform	5	10	15	30.00	37.50	85
Effort*	5	20	37.50	37.78	53.75	75
Frustration	5	5	10	15.79	15	90
Score*	5	25.83	32.92	31.57	35.83	50.83

Table 5.8: RTLX questionnaire overall scores (N=19, *N=18). Full description of questionnaire items can be found in Appendix. E.

Phase	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Design	19	27	30	31.63	38	49
Instant.	26	29	36	37.58	45.50	58
Total	51	61.50	66	69.21	74	101

Table 5.9: Summary of the time cost (minutes) employed for the design and implementation of gamified MOOCs with GamiTool (N=19).

- *"The hard work has been following the tasks reading from the text. Maybe if the tasks are provided with a video explanation + demo of the tool, I could have been able to complete them in less time and effort" [H4:Quest:Part#14].*

While the first case involved external factors which can also happen in a real situation, the high temporal demand is not related to the task itself as stated by the participant. The second case argued that the high temporal demand was due to the time devoted to read the given guide at the same time that participant was configuring the gamification associations. This comment supports the fact that next time using GamiTool the overall perceived workload might be lower. As a future work, we will consider the creation of a video-tutorial to introduce GamiTool and its functionality instead of a textual guide.

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.*, design and instantiating a gamified MOOC (see Table 5.9). Results show that participants dedicated, on average, 37.58 minutes (ranging from 26 to 58 minutes) to perform the digital representation and implementation of a MOOC gamified design for this first time using GamiTool. Spearman's order-rank coefficient was calculated to understand whether temporal demand perception was similar for every participant. Results show non-significant correlation between the perceived and the actual time devoted for the digital representation and implementation of a MOOC gamification ($r(18)$= -0.076, ρ= 0.755). These results confirm that the perceived temporal demand was different for every participant, and therefore, the same time can be perceived as high and low by different participants.

Moreover, the addition of the time that practitioners dedicated to design the gamification (on average, 31.63 min) to the time to digitally represent and instantiate it with GamiTool results, on average, in 69.21 min. Participants were asked in the initial questionnaire about the approximated time to gamify their previous online courses (if applicable). Participants that provided quantitative values mentioned:

- *"[..] depending on the course, perhaps a couple of hours [H1:Quest:Part#6].*
- *"I didn't measure it but more than 40h per course" [H1:Quest:Part#7].*
- *"1 week for each course planing the [gamified] activities" [H1:Quest:Part#12].*
- *"Approx. 5 hours in the design process" [H1:Quest:Part#16].*
- *"2 days" [H1:Quest:Part#19].*

Although the results obtained in this evaluation are not directly comparable with a real situation, considering the automatic support GamiTool support during course enactment (except for monitoring and course privileges manually applied), the average time that they would dedicate to course gamification (*i.e.*, 69.21 min.) is lower than all the answers provided in the initial questionnaire. These results suggest the affordable use of GamiTool for designing and implementing reward-based strategies in MOOCs.

Despite the low RTLX final scores, large differences on participants (5 and 50.83, minimum and maximum values respectively) posed 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 non-significant statistically correlation between the RTLX final score and the previous experience regarding MOOCs and gamification (*r(18)*= -0.035, ρ= 0.889 and *r(18)*= -0.029, ρ= 0.908 respectively). Therefore, the perceived workload of digitally representing and instantiating a gamified MOOC with GamiTool was not related to the previous experience of participants.

Usability

A summary of SUS items and final scores are presented in Figure 5.9 and Table 5.10. As standardized, final SUS score was computed according to the following equation [162]:

$$\begin{aligned} SUS = 2.5(20 + SUM(SUS01, SUS03, SUS05, SUS07, SUS09) \\ -SUM(SUS02, SUS04, SUS06, SUS08, SUS10)) \end{aligned} \tag{5.1}$$

The most common form of interpreting SUS results is the conversion of the SUS score to percentile ranks and letter-grades [251]. Therefore, usability of the evaluated system can be better compared with previous usability evaluations. Results show that the average SUS score obtained (84.61) is above the threshold of 80.3 which represents the lower limit of the top 10% scores obtained over 500 usability evaluations [251]. Accordingly, GamiTool practitioners' perceived usability can be ranked with an A score, representing an *excellent* level of usability [24]. The multiple positive comments provided in the final questionnaire support this high score, some examples are:

- *"I enjoyed using the tool and it has an intuitive interface. It highlights the most important things with colors. It is easy to use [..], and the functions are well integrated since you can deploy it automatically to the MOOC platform" [H4:Quest:Part#1].*
- *"I really liked the tool. I consider it very intuitive and easy to use" [H4:Quest:Part#8].*
- *"I felt quite confident using tool after having having done 2 associations (the one in the "tutorial" and the first one by myself)" [H4:Quest:Part#11].*
- *"I have found the tool easy to use in combination of the PDF guide provided" [H4:Quest:Part#13].*
- *"I like a lot the tool, I think the interface is really nice and easy to use" [H4:Quest:Part#14].*
- *"I think some of the interface can be made more intuitive and some options simplified but overall it is well designed" [H4:Quest:Part#15].*
- *"I think this tool is an easy way to start gamifying any online or blended learning course" [H4:Quest:Part#18].*

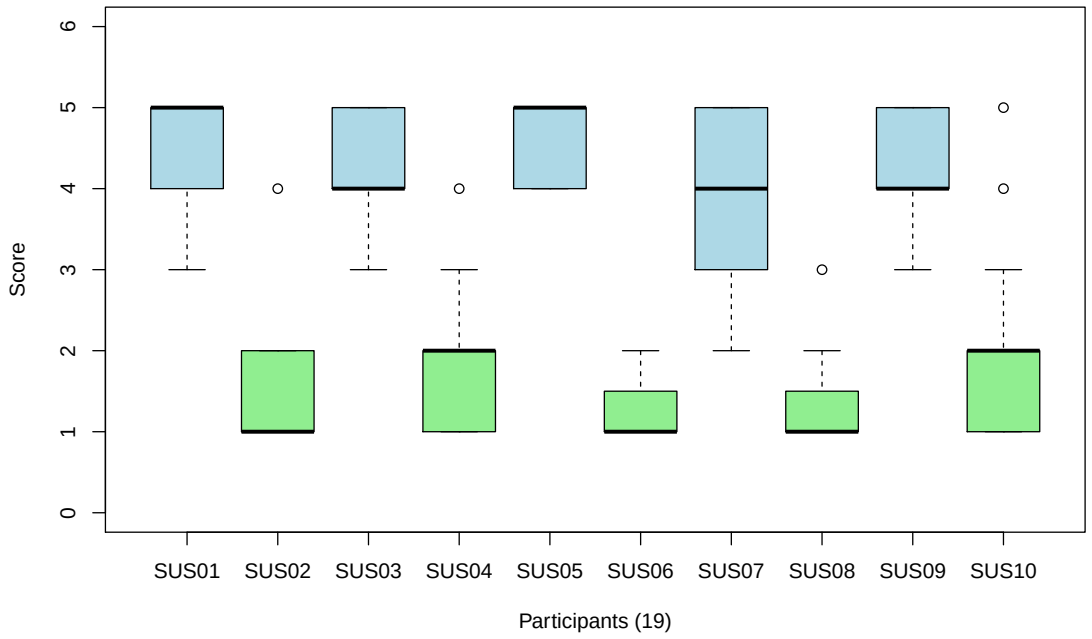


Figure 5.9: SUS questionnaire overall results (plot).

Item	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
SUS01	3	4	5	4.47	5	5
SUS02	1	1	1	1.53	2	4
SUS03	3	4	4	4.37	5	5
SUS04	1	1	2	1.79	2	4
SUS05	4	4	5	4.68	5	5
SUS06	1	1	1	1.26	1	2
SUS07	2	3	4	3.95	5	5
SUS08	1	1	1	1.32	1	3
SUS09	3	4	4	4.26	5	5
SUS10	1	1	2	2.00	2	5
Score	72.50	78.75	85.00	84.61	90.00	100.00

Table 5.10: SUS questionnaire overall scores (N=19). Full description of questionnaire items can be found in Appendix. E.

Item	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Likelihood-to-recommend	7	9	10	9.42	10	10

Table 5.11: Summarized participants' scores on how likely they would recommend GamiTool to others.

Adoption

Three participants noted in the initial questionnaire (previous to GamiTool introduction) the constraints of current MOOC platforms (*e.g.*, EdX, Canvas Network) and gamification systems, hindering the application and adoption of gamification in MOOC environments:

- *"I use edX as an LMS. I have not used gamification tools because we use a basic instance of edX where gamification tools have not been implemented yet. However, we are looking forward to start integrating external gamification tools/applications with our LMS, as well as exploring different LTIs enabling this functionality" [H1:Quest:Part#3]*
- *"I only used gamification when the tool to support the activity was already developed" [H1:Quest:Part#11].*
- *"I spent the time researching and testing the various ways to gamify content, however there were a lot of limitations, for example there are not many gamification tools that are suitable for Canvas" [H1:Quest:Part#19].*

Additionally, a couple of participants also reported the use of gamification in traditional University (*e.g.*, face to face and blended learning) instead of MOOCs:

- *"I have applied some gamification in my f2f courses, but never in the online ones" [H1:Quest:Part#13].*
- *"I use gamification more in face to face settings (e.g., Kahoot!, Socrative or Mentimeter in-class for synchronous interaction)" [H1:Quest:Part#6].*

All these previous comments remark the limitations of current MOOC and gamification systems as identified in previous chapters, and highlights the importance of configurable gamification tools for different MOOC platforms and gamification purposes, thus supporting its adoption.

Apart from the *SUS01* item referring to participants' frequent use of GamiTool (minimum value = 3/5, median value = 5/5, mean value = 4.47/5), tool adoption was also measured through the NPS [231]. 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) [231]. The NPS obtained in this evaluation is 89.47 (minimum selected value = 7/10, median selected value = 10/10, mean selected value = 9.42/10). According to Reichheld (2003) [231], this high score (over 75.00) corresponds to a product from which "companies garner world-class loyalty", thus supporting its potential for tool adoption. Participants' additional comments in the final questionnaire and the observations gathered during the evaluation confirm such adoption for (experienced and non-experienced) practitioners teaching practice:

- *"I learned while doing these tasks, and thought about I could enhance the participants learning and engagement of my courses by using GamiTool functionalities" [H4:Quest:Part#3].*
- *"I would love to use it in Open edX" [H4:Quest:Part#6].*

- *"I would like to use it in Moodle for a project involving the development of teachers' capacities in Higher Education" [H3:Obs:Part#18].*
- *"I would like to use it in my Moodle courses at the uni. I see it is valid also for these courses, not only for MOOCs" [H4:Quest:Part#11].*

5.3.5 Discussion

Results from this second evaluation revealed that GamiTool-DM supported the representation of most gamification designs created by evaluation participants. Entering into more detail, GamiTool-DM was able to: support 45.07% conditions, partly-support 39.44% semantic conditions, and support with minor changes 14.08% conditions. Considering that: (1) semantic conditions (*e.g.*, quality of a submitted task) can be either represented with quantitative (*e.g.*, getting a high score in the peer review of such task) or with peer approval (*e.g.*, a certain number of peers confirm the high quality of the submission) conditions which are actually supported by GamiTool-DM; and, (2) minor changes have been already applied to GamiTool-DM; GamiTool currently supports and party-supports the 59.15% and 45.07% respectively of the conditions proposed by evaluation participants.

Similarly, GamiTool-DM was able to: support 70.42% rewards, partly-support 7.04% rewards, and support with minor changes 14.08% rewards. Considering that: (1) partly-supported rewards involve rewards which are supported by the model but whose issuing form is different; and, (2) minor changes have been already applied to GamiTool-DM; GamiTool currently supports the 91.55% of the rewards proposed by evaluation participants; GamiTool currently supports and partly-supports the 84.5% and 7.04% respectively of the rewards proposed by evaluation participants.

It is worth to mention that one limitation of this evaluation is the creation of gamification designs over a given real MOOC which was not known by participants beforehand. The limited number of GamiTool adapters developed for importing learning designs from MOOC platforms (Canvas- and Moodle-based platforms), and the limited time for the evaluation case study (2 hours per participant), encouraged us to make this decision. In order to minimize this limitation, course goals and activities were described in the evaluation worksheet, and participants could edit the MOOC learning design according to their purposes, as some of them did. As a future work, we plan to repeat the same evaluation task with participants' own MOOC learning designs in order to obtain more precise results regarding GamiTool-DM design expressiveness.

Besides, GamiTool-DM was initially developed with the purpose of allowing the digital representation and automation of complex gamification designs in MOOC environments. Results showed that the pool of condition and reward types of GamiTool-DM were perceived as useful for this purpose, especially for those practitioners less experienced with gamification. Further work could involve the investigation of these elements considered as important during the conceptualization and design of gamification strategies (*e.g.*, gamification purposes) and incorporate them into GamiTool-DM (and GamiTool), thus supporting the whole life-cycle of gamified learning situations.

Results also showed an excellent tool usability being very likely to be recommended to other practitioners for including reward-based strategies on their courses. Furthermore, the general perceived workload of digitally representing and implementing a gamified

MOOC design was low although we observed room for improvement for the mental demand and effort sub-scales.

The additional comments provided by participants in the NASA-RTLX questionnaire suggest that the relatively high mental demand and effort reported was due to the fact of learning how to use a tool for the first time (while reading the guide and doing the task at the same time). In order to confirm that both high values were due to the initial cognitive curve of learning how to use a tool, we foresee the realization of a longitudinal study following the same evaluation happenings with the same evaluation participants [94]. Therefore, being the previous experience with GamiTool the dependent variable of the study, we can explore the differences on questionnaire scores to such variable. Additionally, we consider the development of a tool wizard guiding users for the first time they use the tool to decrease the task workload for first-time users.

5.4 Conclusions

In the previous chapter, GamiTool (including GamiTool-DM and GamiTool-ARCH) was proposed as a tool to help overcome the limitations of current MOOC platforms and gamification systems regarding features supporting their design expressiveness and practitioners' affordability and adoption. This chapter described two evaluation studies carried out to understand the extent to which GamiTool is able to represent practitioners' MOOC gamification designs, and the different factors affecting to its affordability for digitally representing, instantiating and managing MOOCs involving reward-based strategies.

The first evaluation study involved one practitioner who used GamiTool to design, instantiate and manage a MOOC incorporating reward-based strategies in which she was the main instructor of the course. According to the participant, GamiTool was useful for the design and redesign of the conceptualized gamification design, and was affordable in terms of cognitive load and time for the digital representation, instantiation and management in a real MOOC. These positive results confirmed the right direction toward accomplishing the second and third dissertation goals, and provided useful insights to keep improving GamiTool. Nevertheless, this evaluation was performed by a single practitioner who sometimes needed the support of researchers to perform the implementation and management of gamification strategies, thus posing the need for a second summative evaluation to confirm the attainment of the aforementioned dissertation goals.

The second evaluation was performed after implementing the main insights for improvement from the first evaluation. This evaluation involved 19 MOOC practitioners and/or gamification designers from 10 different educational institutions located in 6 different countries, with different previous MOOC and gamification experience. Results from the second evaluation showed:

a. The GamiTool-DM high level of support to the gamification designs created by MOOC practitioners, leading us to confirm that it enables practitioners the representation of MOOC learning designs involving reward-based strategies with a fine-grain reward and completion logic.

b. The positive results obtained regarding tool usability, tool adoption, and task workload with GamiTool, leading us to confirm that GamiTool made cognitively and

timely affordable for practitioners the design, instantiation and management of reward-based strategies in MOOCs.

Although the sample size of this second evaluation (N=19) is in the range of 5-50 participants as recommended for traditional usability evaluations [5], more evaluations involving other MOOC practitioners and in real learning situations would be recommended to better understand the impact that GamiTool might have in the current MOOC landscape.

Chapter 6

Conclusions and Future Work

Summary: This chapter presents the overall conclusions of the dissertation, summarizing the main research problem (*how to support practitioners in the orchestration of reward-based strategies in MOOC environments to promote students' behavioral engagement*), and the proposed goals and contributions. The results obtained during the evaluative studies provided enough evidence about the achievement of such goals. The outcomes obtained from the empirical studies lead us to formulate future research lines of potential research work. The contents of this dissertation have been published in two JCR-SCI peer-reviewed journals and in four international conferences, thus supporting the relevance, originality and importance of this dissertation goals and contributions. These publications also support the relevance of the research work described in this dissertation.

6.1 Conclusions

The inclusion of reward-based strategies in MOOC environments are expected to produce potential benefits (*e.g.*, promote student behavioral engagement), based on the results reported in other educational environments. However, the addition of these strategies implies a number of orchestration tasks that have to be carried out by course practitioners. Given this context, this dissertation aims to support MOOC practitioners in the design, instantiation and management of reward-based gamification strategies in MOOC environments to promote students' behavioral engagement.

Consequently, at the beginning of this dissertation, we explored the current body of research regarding gamification in MOOCs. To this end, we conducted a systematic literature review as reported in Chapter 2. The systematic literature review showed the novel and immature state of this research area. Additionally, the review also helped to identify the most frequent gamification design purposes (*e.g.*, increase student engagement and motivation), game design elements (*e.g.*, badges, leaderboards), gamification conditions (*e.g.*, interacting in forums, completing course tasks) and learning platforms (*e.g.*, Moodle, iMOOX) used in gamified MOOC contexts. This literature review have been partially published in [210].

Besides, the literature review identified a set of limitations and research gaps of current publications dealing with gamification in MOOCs. One of the most relevant con-

straints was the limited number of empirical studies performed in real MOOC environments. These studies presented diverse types of gamification designs, gamification purposes, and evaluation methods, thus hindering the understanding of the effect of reward-based strategies on student engagement. Consequently, we formulated the first goal of this dissertation: *To understand the effects on student behavioral engagement of reward-based strategies in real MOOC contexts*. To this end, we carried out three empirical studies aiming to understand and compare the effect of reward-based strategies on student behavioral engagement in real MOOC environments (see Chapter 3).

Results showed that reward-based strategies had, in general, a positive impact on student behavioral (*e.g.*, number of pageviews and submitted tasks), and on reward-derived engagement (*e.g.*, number of earned rewards, claiming time span). The empirical studies helped to understand the positive correlation between variables measuring both types of engagement, and the importance of the gamification design to successfully achieve the expected gamification benefits (*e.g.*, some strategies were more pursued than others). Furthermore, during the three courses, we observed that the effect of these strategies decreased throughout the course, and that while some students attempted to earn all course rewards, others, intentionally avoided them (mainly due to their interest on learning and lack of time). These studies have been partially published in [211, 207, 206].

The three empirical studies contribute to the current body of research, providing incremental evidence about the positive effects of reward-based strategies to increase student behavioral engagement and drive student behavior (*e.g.* increase task participation, promote learners' interaction). The observed gamification benefits, and the orchestration constraints observed during the provision of the three empirical studies, led us to further investigate the role of practitioners during the gamification life-cycle of MOOCs involving reward-based strategies. As a consequence, we performed a systematic feature analysis of current MOOC platforms and gamification sytems to find out to which extent they support the orchestration of reward-based strategies (see Chapter 4).

The feature analysis revealed important limitations of current systems and MOOC platforms, regarding the digital representation of gamified MOOCs (*e.g.*, conditions in MOOC platform native tools, course privileges), and their affordable use (*e.g.*, lack of usable interfaces). Given this situation, MOOC practitioners were forced to either manually implement and manage reward-based strategies, or to adapt their gamification designs to the restricted capabilities of current gamification systems. These conclusions led us to specify the second and third goals of this dissertation as follows: *To enable the computer-interpretable representation of MOOC learning designs involving reward-based strategies according to practitioners' decisions*; and, *To make cognitively and timely affordable for practitioners the design, instantiation and management of reward-based strategies in MOOCs*.

In order to accomplish these goals, we proposed the development of a system (*i.e.*, GamiTool) implementing, (a) a data model (*i.e.*, GamiTool-DM) and (b) a system architecture (*i.e.*, GamiTool-ARCH). Following the iterative nature of the methodology followed in this dissertation (SDRM), these proposals and the developed prototype (complementing the system usability features) were refined after every evaluation study. A preliminary version of the GamiTool system has been published in [208].

Two formal evaluation studies were performed to understand the extent to which

GamiTool accomplished the second and third goals of this dissertation (see Chapter 5). The first evaluation involved one instructor who used GamiTool to re-design, instantiate and manage reward-based in a second version of a MOOC in which she was involved. The formative feedback obtained from the first evaluation study provided useful insights for the refinement of GamiTool.

The second evaluation involved 19 MOOC practitioners and/or gamification designers who proposed their own gamification design, and used GamiTool to digitally represent and instantiate a given gamification design into a MOOC. The evaluations showed that GamiTool-DM is able to represent most gamification designs created by MOOC practitioners, thus validating the second goal of this dissertation (*OBJ#2_EXP*). Additionally, according to the evaluation participants, GamiTool supports the affordable digital representation, instantiation and management of MOOC involving reward-based strategies, thus confirming the attainment of *OBJ#3_AFF*. Furthermore, although it was not conceived as an objective of this dissertation, we also observed that GamiTool provided some guidance to practitioners during the design of gamified learning designs, supporting the selection of rewards and conditions on their learning designs.

In summary, this dissertation has tackled the issue of supporting practitioners in the orchestration of reward-based strategies with the purpose of promoting students' behavioral engagement. To this end, three empirical studies helped to understand the effect of these strategies on student behavioral engagement, thus providing insights for the successful design of future gamified MOOCs. Additionally, we developed a fully-functional prototype of the proposed GamiTool system, supporting the affordable design, instantiation and management of these strategies in MOOCs, as reported by MOOC practitioners.

6.2 Future Lines of Work

The contributions proposed and the goals accomplished in this doctoral dissertation have also enabled the identification of future research lines around the topic of gamification in MOOCs, and its orchestration. These future research lines have been classified into (a) research extensions of the dissertation outcomes, and (b) potential applications of the dissertation contributions into emerging TEL research areas.

Research Extensions

This subsection presents future research lines of work associated with the goals pursued in this dissertation:

- One of the main outcomes of the systematic literature review described in Chapter 2 is the lack of empirical studies regarding the effect of gamification strategies in real MOOC environments. As observed in Chapter 4, one of the indirect causes of such low number of studies is the limited capabilities of current MOOC platforms. The development of GamiTool has enabled a number of possibilities to continue exploring and understanding the effects of reward-based gamification in MOOC contexts. Researchers could use GamiTool to investigate the effect of gamification designs (disregarding the MOOC platform used), in ways that were not feasible

or affordable with the existing gamification tools. The outcomes of these works could complement the design guidelines presented in Chapter 3 to foster learners' behavioral engagement in MOOC environments.

- As observed in small-scale contexts, and as gathered during the evaluation studies performed within this dissertation, gamification is frequently used with multiple educational purposes (*e.g.*, increase student learning outcomes, promote collaboration in group tasks). In this dissertation, we have focused on studying the effect of reward-based strategies on student behavioral engagement. Nevertheless, it is worth exploring the extent to which gamification strategies in MOOC environments can be also effective for other pedagogical purposes. Therefore, practitioners could be provided with design guidelines according to the expected gamification benefits to be obtained, thus facilitating the design process.

- During the evaluation studies, we observed that the hints (*i.e.*, conditions and rewards) provided by GamiTool, were useful for the creation of the gamification design. We could further explore this issue by developing predefined gamification templates that can support practitioners in the effective application of gamification strategies and supporting their affordable design. These templates should consider both the learning design of the course (*e.g.*, pedagogical goals, activity types) and the aforementioned gamification design guidelines.

- Results revealed that some students felt motivated by rewards, some other students participated in specific reward strategies, and some others avoided gamification in general. Therefore, it seems interesting to explore to what extent personalized gamification could make students more proactive to attain course rewards. For instance, different reward strategies could be proposed to each student based on their actions within course contents and activities (*e.g.*, competitive students are invited to participate in a leaderboard competition to obtain course privileges).

- One of the current limitations of GamiTool is the necessity of importing the learning designs to be gamified from the MOOC platforms. Therefore, practitioners need to first configure *ad-hoc* the learning designs directly in the MOOC platform, to later gamify them in a different platform (*i.e.*, GamiTool). The integration of GamiTool within learning-design authoring tools for MOOC platforms would unify the gamification design process. Given this situation, we foresee the integration of GamiTool within existing learning-design authoring tools or environments such as the Integrated Learning Design Environment (ILDE) [123].

- Furthermore, GamiTool prototype is close to be a final product which could be used by practitioners within their teaching practice, and without the need of administrators, developers and/or researchers. Taking advantage of this feature, and with the aim of using the main dissertation's contributions out of the dissertation context, we plan to include GamiTool into educational tool repositories (*e.g.* EduApp center[1]) and make internal and external promotion (*e.g.*, training workshops) to support its

[1]EduAppCenter: *https://www.eduappcenter.com/*, last access: September, 2020

use. As part of this future plan, we will consider the use and adoption of GamiTool by those evaluation participants that stated their interest on using it in their courses (including MOOCs and blended-learning courses). Some of these participants offer their courses over Open edX-based platforms, so that we also plan to develop GamiTool adapters for this type of instances in a near future.

Potential Applications

Some of the work performed within the context of this dissertation has led to the proposal of potential applications of gamification in educational contexts. However, differently from the previous ones, these are emergent research lines, which are not directly related to the goals of the dissertation.

- Use of gamification analytics to predict learners' behavior in online courses, including MOOCs: The prediction of the future behavior of participants during the first weeks of online courses, specially in the case of MOOCs, can help practitioners to better design and re-design learning activities in the following weeks such as those involving peer revisions or group activities [86]. The empirical studies performed within this dissertation showed a statistical significant correlation between variables measuring reward-derived engagement and the variables measuring behavioral engagement. Therefore, the student interaction with the gamification elements during the first weeks of the course can potentially contribute to better predict the number and type of active participants in the following weeks. Given this context, variables such as the number of claimed and earned rewards, privileges to be redeemed in future weeks, participation in gamified quizzes, etc. can serve as additional input to the method used to predict future student behavior within the course.

- Orchestration of gamification in the *New Normal Education*: With the recent venue of the covid-19 pandemic outbreak, governments are restricting the maximum number of concurrent persons in closed spaces, thus affecting to the traditional forms of teaching and learning. Therefore, learning institutions (*e.g.*, schools, universities) whose teaching methods include face to face and blended learning methods are adopting new hybrid learning approaches able to adapt to changes from/to 100% physical instruction, 100% online presence, or intermediate scenarios where some students are physically located in the classroom while others are digitally connected [2]. Consequently, this new situation poses new difficulties in the orchestration of these learning situations such as managing interactions between learners, managing groups, task submissions, etc. Gamification is a technique that can be applied to both face to face and online situations, and which could help smooth the gap between both learning spaces at the same time that students are engaged, specially for children. Therefore, it is worth to explore the extent to which current learning tools support the orchestration of gamification given this hybrid situation, and which gamification strategies better promote this goal.

[2]World Heath Organization (2020). Considerations for school-related public health measures in the context of COVID-19. Retrieved from: *https://www.who.int/docs/default-source/coronaviruse/who-2019-ncov-adjusting-ph-measures-schools-2020-1-eng.pdf*, last access: September, 2020

6.3 Publications and Research Projects

The number of publications related to the work described throughout this dissertation and the associated research projects highlight the relevance and success of this research.

6.3.1 Publications

This subsection lists the different published documents describing part of the work and the results obtained from this research process. The list only includes peer-reviewed publications in which the dissertation author is first author.

Publications in JCR-indexed international journals:

J1. [JCR-SCI Q2] Ortega-Arranz, A., Er, E., Martínez-Monés, A., Bote-Lorenzo, M.L., Asensio-Pérez, J.I. & Muñoz-Cristóbal, J.A. Understanding Student Behavior and Perceptions towards Earning Badges in a Gamified MOOC. *Universal Access in the Information Society*, 18(3) pp. 533–549, 2019. DOI: 10.1007/s10209-019-00677-8

J2. [JCR-SCI Q1] Ortega-Arranz, A., Bote-Lorenzo, M.L., Asensio-Pérez, J.I., Martínez-Monés, A., Gómez-Sánchez, E. & Dimitriadis, Y. To Reward and Beyond: Analyzing the Effect of Reward-Based Strategies in a MOOC. *Computers & Education*, 142, 103639, 2019. DOI: 10.1016/j.compedu.2019.103639

Publications in international conference proceedings:

C1. Ortega-Arranz, A., Sánz-Martínez, L., Álvarez-Álvarez, S., Muñoz-Cristóbal, J.A., Bote-Lorenzo, M.L., Martínez-Monés, A. & Dimitriadis, Y. From Low-Scale to Collaborative, Gamified and Massive-Scale Courses: Redesigning a MOOC. In Proceedings of the *5th European MOOC Stakeholders Summit (eMOOCs)*, pp. 77–87, 2017. DOI: 10.1007/978-3-319-59044-8_9

C2. [Google Scholar H5-16] Ortega-Arranz, A., Muñoz-Cristóbal, J.A., Martínez-Monés, A., Bote-Lorenzo, M.L. & Asensio-Pérez, J.I. How Gamification is Being Implemented in MOOCs? A Systematic Literature Review. In Proceedings of the *12th European Conference on Technology-Enhanced Learning (EC-TEL)*, pp. 441–447, 2017. DOI: 10.1007/978-3-319-66610-5_40

C3. [Google Scholar H5-20] Ortega-Arranz, A., Kalz, M. & Martínez-Monés, A. Creating Engaging Experiences in MOOCs through In-Course Redeemable Rewards. In Proceedings of the *2018 Global Engineering Education Conference (EDUCON)*, pp. 1875–1882, 2018. DOI: 10.1109/EDUCON.2018.8363464

C4. [Google Scholar H5-11] Ortega-Arranz, A., Muñoz-Cristóbal, J.A., Martínez-Monés, A., Bote-Lorenzo, M.L. & Asensio-Pérez, J.I. A System for Gamifying Ubiquitous Learning Situations Supported by Multiple Technologies. In Proceedings of the *13th International Conference on Intelligent Tutoring Systems (ITS)*, pp. 439–440, 2016. DOI: 10.1007/978-3-319-39583-8

Publications in Spanish conference proceedings:

C5. Ortega-Arranz, A. & García-Sastre, S. ¡MOOC!¡MOOC!¿Quién Es? El Aprendizaje Colaborativo llama a las puertas de los MOOC. *Congreso Internacional de Educación y Tecnología (EduTec)*, pp. 188–189, 2016. ISBN: 978-84-9921-847-2

6.3.2 Research Projects

This subsection lists those research projects close related to the work performed within the context of this dissertation, in which the work carried out in this dissertation has contributed to accomplish their fulfillment:

P1. RESET-UVa: Reformulate Scalable Educational Ecosystems Offering Technological Innovations. Date: 2015-2019. Funding entity: Spanish Ministry of Science and Innovation (TIN2014-53199-C3-2-R). Principal Investigator: Yannis Dimitriadis and Eduardo Gómez-Sánchez. Fund: 138,899.99€.

P2. SideMagic4MOOC: Sistema integrado para el diseño, ejecución y monitorización del aprendizaje gamificado y colaborativo en cursos online masivos. Date: 2016-2018. Funding entity: Regional Government of Castilla y Leon (VA082U16). Principal Investigator: Yannis Dimitriadis. Fund: 117,010.00€.

Additionally, the knowledge generated as a consequence of this thesis dissertation helped to contribute to the following topic-related projects:

P3. ColMOOC: Integrating Conversational Agents and Learning Analytics in MOOCs Date: 2018-2020. Funding entity: Erasmus+ Programme KA2, European Commission (588438-EPP-1-2017-1-EL-EPPKA2-KA). Principal Investigator: Yannis Dimitriadis. Fund: 108,120.00€.

P4. SmartLET-UVa: Analítica del aprendizaje para mejorar el diseño y la orquestación en entornos inteligentes de aprendizaje escalables y ubicuos, enriquecidos con internet de las cosas. Date: 2018-2020. Funding entity: Spanish Ministry of Science and Innovation (TIN2017-85179-C3-2-R). Principal Investigator: Yannis Dimitriadis and Miguel L. Bote-Lorenzo. Fund: 136.851,00€.

Appendix A

Evaluation Questionnaires

This appendix includes the evaluation questionnaires implemented in the last module of the three empirical studies described in Chapter 3 in order to collect students' perceptions about reward-based strategies. Questionnaires were provided online and implemented in the last module of the course with the Canvas Network quiz tool as a compulsory activity to obtain the course completion certificate. Original questionnaires also implemented questions about gamification non-related topics (*e.g.*, course experience, preferred modules) which have been removed from this appendix. Questionnaires' content-related evidence of validity (*i.e.*, definition, sample, content and format) [94] was obtained by three TEL research experts from GSIC-EMIC group (and one course student in TraduMOOCv1). TraduMOOCv1 and TraduMOOCv2 questionnaires were translated from Spanish (course main language) to English.

A.1 TraduMOOCv1

The following statements are related to the badges of the course. Grade your degree of agreement with the following statements, or mark "Don't know / No answer" in case you don't have an opinion. At the end of this section there is a text box where you can add extra comments related to the statements.

1. **The possibility of earning badges increased my motivation to complete course activities.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

2. **Earning the different course badges encouraged me to participate in peer reviews.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

3. **Earning the different course badges encouraged me to participate in quizzes.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

4. **Earning the different course badges encouraged me to participate in group activities.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

5. **Earning the different course badges encouraged me to participate in the glossary.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

6. **Earning the different course badges encouraged me to participate in discussion forums.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

7. **Earning the different course badges made me visit more course pages.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

8. **Earning the different course badges made me complete more course tasks.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

9. **Earning the different course badges made me spend more time in the course.**

   [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

10. **I tried to earn badges because I liked to collect them.**

    [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

11. **I tried to earn badge because they showed my progression in the course.**

    [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]

12. **I tried to earn badges because I competed with other students.**
    [Strongly agree | Agree | Disagree | Strongly disagree | Don't know / No answer]
13. **Additional comments about course badges and the leaderboard (optional).**
    [Open-answer]

A.2 CLaTMOOC

The following questions are related to the quizzes and badges of the course. Grade your degree of agreement with the following questions (don't answer them in case you don't have an opinion). At the end of this section there is a text box where you can add extra comments related to the quizzes and badges.

1. **The quizzes have been useful to learn new concepts about collaborative learning and/or ILDE.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

2. **Trying to earn the different badges encouraged me to participate in the quizzes.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

3. **Trying to earn the different badges encouraged me to spend more time in the course.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

4. **Trying to earn the different badges encouraged me to visit more pages of the course.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

5. **Trying to earn the different badges encouraged me to interact with other students of the course.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

6. **I tried to earn the different badges because I liked to collect them.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

7. **I tried to earn the different badges because they showed my progress in the course.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

8. **I tried to earn the different badges because I competed with other students.**

   [Strongly Disagree | Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Agree | Strongly Agree]

9. **Other reasons, effects and/or general comments about the quizzes and badges.** [Open-answer]

A.3 TraduMOOCv2

This questionnaire was provided to experimental groups: BADGE and REDEEM.

¡Hello participants!
This survey aims to better understand your experience with course rewards in order to improve for future versions.

1. **What rewards (privileges for the REDEEM group) did you like most and least? Why?**

   [Open-answer]

2. **Other comments (let us know any comment related to course rewards).**

   [Open-answer]

Appendix B

Feature Analysis Score Sheet

This appendix includes the questionnaire template (*i.e.*, score sheet) used during the feature analysis described in Chapter 4. The analysis aimed to identify the features of current gamification systems that can be used in MOOC environments regarding three topics: design expressiveness, practitioners' affordability and adoption, and learners' experience. The feature analysis followed the guidelines proposed for the screening mode in the DESMET methodology [149]. Four assessors reviewed, with the help of the following score sheet, 8 different systems ensuring that each system was reviewed by at least 3 different assessors. The score sheet included a summary of each feature to be analyzed (summarized description), the rubric (feature score) and the questionnaire itself including the score for each feature, the evidence for such score and additional comments.

B.1 Score Sheet

Feature	Summarized Description	Feature Score
[DE1] Multiple types of rewards	Practitioners use different types of rewards (e.g., points, badges, trophies, levels, virtual goods) as reported in the literature. The system should provide support to the use of different types of rewards.	0: Support to 1 type of reward 1: Support to 2 different types of rewards 2: Support to 2+ different types of rewards
[DE2] MOOC In-course privileges	In-course privileges have been identified as a potential game element to increase student engagement in MOOCs. The system should provide support to course privileges connected with activities and tools typically used in MOOC environments (e.g., deadline extentions, extra attempts, unlock content).	0: No support to in-course privileges 1: Support to in-course privileges in a single tool/activity (e.g., only privileges associated to quizzes) 2: Support to in-course privileges in multiple tools/activities
[DE3] Previous earned rewards	Based on previous studies, sometimes, practitioners provide rewards based on previous earned rewards (e.g., a student level up, when 1000 points are earned, a student receives a special badge when 3 badges are earned). The system should provide support to this kind of completion logic.	0: No support to conditions based on earning previous rewards 1: -- 2: Support to conditions based on earning previous rewards
[DE4] MOOC frequent activities	Based on previous studies, in most cases, rewards are issued when learners perform certain action/s within the MOOC. The system should provide support to conditions associated to learners' actions performed in frequent MOOC activities and tools (e.g., discussion forums, quizzes, assignments, peer reviews, content materials). If the system only allows to gamify a single (or two) activity or tool, we will consider it as "No support" since it supposes a strong limitation in the majority of MOOCs which usually implement at least (1) content pages, (2) quizzes, (3) dicussion forums and (4) assignments (reference needed for this assumption).	0: Support to conditions associated to a single type of learning activity described in the summary 1: Support to conditions associated to 2 different types of learning activities described in the summary 2: Support to conditions associated to 2+ different types of learning activities described in the summary
[DE5] Fine-grain rules	Based on previous studies, in most cases, rewards are issued when learners perform certain action/s within the MOOC. Sometimes these actions are configured as-is or pre-fixed by the systems (e.g. submit assignment, get full score in quizzes). However, some practitioners encourage learners to perform concrete actions that needed fine-grained rules (e.g. submit an assignment before a specific date, get a higher percentage than 60% in a quiz). The system should provide support to desgin and configure fine-grained rules in frequent MOOC activities and tools.	0: Support to only 1 type of action as condition for every supported tool (e.g., quizzes --> submit quiz) 1: Support to 2 different types of actions as conditions for every supported tool (e.g., quizzes --> submit quiz & get an upper score than X) 2: Support to 2+ different types of actions as conditions for every supported tool (e.g., quizzes --> submit quiz & get an upper score than X & do it before a concrete date)
[DE6] Group conditions	Teachers could configurate rewards that are issued when a specific percentage of team members perform a concrete action, thus estimulating them to promote peers to complete the actions and therefore increasing the interaction among group members.	0: No support to conditions based on team members 1: -- 2: Support to conditions based on team members
[DE7] Peer approval	Based on previous studies, sometimes, practitioners decide to leave the decision either a student satisfied the reward conditions or not to other team members (e.g., based on the work done for a collaborative task) (e.g. Cross2014). Therefore, the system should give this possibility to designers.	0: No support to peer approval (i.e., group peers will determine if you satisfied the conditions or not) 1: -- 2: Support to peer approval conditions
[DE8] Configurable associations	Some systems are limited to pre-fixed completion logics (i.e., conditions) and reward types. This way, practitioners cannot encourage learners to perform concrete conditions that they believe benefitial for their learning (for example, by issuing a higher quantity of rewards in a concrete condition). The system should provide freedom to select the type or types of conditions and the quantity and type of rewards.	0: Pre-fixed conditions and reward types and quantities 1: Pre-fixed conditions and reward types 2: Freedom to associate conditions with reward types and quantities
[PA1] MOOC-technology independent	There is no a predominant MOOC-platform and usually the MOOC platform is imposed by the institution. The system should provide support to as many MOOC platforms as possible. Clarification: different instances of a same platform does not count as different MOOC platforms.	0: Gamification can be only implemented in a single platform 1: Gamification can be only implemented in a single MOOC platform 2: Gamification can be implemented in multiple MOOC platforms
[PA2] Integration with external tools	In many cases, MOOCs offer additional activities through tools external to the MOOC platform (e.g., Twitter, Google Spreadsheets, H5P). The system should provide support to the design and management of gamification performed within these external tools.	0: Gamification is restricted to the actions performed within the tools of the MOOC platform 1: Gamification can be implemented with a single tool external to the MOOC platform 2: Gamification can be implemented with multiple tools external to the MOOC platform
[PA3] Usable for practitioners	In order to support the practitioners' adoption of reward-based gamification in MOOCs it is desirable that the tools used to design, deploy and enact are easy to use for them. Since the 'easy-to-use' feature is in most cases a subjective opinion, we will consider a tool easy to use (i.e., "Full Support") when a 'usability evaluation' with practitioners and/or researchers has been performed with a positive result for the authors.	0: No usability evaluation has been performed 1: Usability evaluation with MOOC practitioners has been performed with no positive results for the authors 2: Usability evaluation with MOOC pratcitioners has been performed with positive results for the authors
[PA4] Analytics support	Instructors should be aware of the gamification situation during course runtime (e.g., how many rewards have been issued, to who) to understand if the implemented rules are too easy or too difficult, and if it is necessary to change them. Additionally, instructors aware of the gamification situation can better address possible problems from students. The system should provide support to some kind of gamification analytics to course instructors/practitioners (no researchers) during course runtime.	0: No support to gamification analytics for instructors during course runtime 1: Support to non real-time gamification analytics for instructors 2: Support to real-time gamification analytics for instructors
[PA5] Changes during enactment	In most cases, MOOC instructors do not know the number and profile of students that will enroll before creating the gamification design of the course. This can lead to the design of too easy or too difficult conditions (e.g., receive more than 100 likes in a post in a week with 90 active students). Additionally, instructors can perform mistakes in the design of gamification (e.g., configure a condition in a quiz which was not expected). The system should provide support to the edition of the gamification design during course runtime (e.g., change the threshold of a conditions, add more rewards, remove conditions)	0: No changes in the gamification design are allowed during the course enactment 1: -- 2: Changes during course runtime are allowed.
[PA6] Automated issuing procedure	The massive number of worldwide enrolled students in MOOCs make the manual issuing of rewards by instructors unaffordable in terms of time and cognitive effort. The system should provide support to the automatic handle of learners' requests, check the satisfaction of conditions, issue the corresponding rewards and record it in the database.	0: Support to manual rewarding 1: -- 2: Support to automated rewarding
[PA7] Quick database access	The large number of enrolled students in MOOCs arises the possibility that the gamification system have to handle many issuing procedures in a short period of time. The quick learners feedback is high recommendable (ref). In this case, we will consider as "Full support" when the system was evaluated with 500+ enrolled students with the learner role.	0: System not evaluated regarding this issue. 1: System evaluated in non-real contexts (e.g., simulated students) or in real environments with 500- enrolled learners in the same course 2: System evaluated in real contexts with 500+ enrolled learners in the same course
[LE1] Gamification seamless integration	When using third party gamification tools, sometimes learners have to re-login into a different system (embedded or non-embedded into the course). This can cause students to be reluctant to use gamification and disengage within the gamification and/or the course. The system should provide a seamless integration with the course (i.e., being integrated with the course contents and activities) without the need of re-logging (e.g., supporting IMS-LTI). Clarification: if the gamification system is part of the MOOC platform, we will consider a seamless integration of the gamification system and provide a (2) score to the system in this feature.	0: The gamification platform is external to the MOOC platform where most of the contents and activities are performed 1: The gamification platform is integrated with the course contents and activities but students need to re-log-in 2: The gamification platform is integrated with the conruse contents and activities and students don't need to re-log-in
[LE2] Claiming/Disable option	According to previous studies, there exist different player profiles in online gamified environments. Learners included in some of these profiles identify gamification as non-interesting and/or non-motivating. In order to avoid unexpected effects in those students caused by gamification features, the system should provide students the possibility to choose whether interact with the implemented gamification features or not/ or to claim them or not. Clarification: The system should be the one providing the opportunity to learners to participate in the gamification (not the design study performed by researchers).	0: Students don't have the possibility to choose whether participate in the gamification or not 1: Students have the possibility to choose whether participate in the gamification or not 2: Students have the possibility to claim the rewards they are interested to
[LE3] Usable for learners	In order to promote students to use the gamification system and to avoid course disengagement. the system should be easy to use for learners. Since the 'easy-to-use' feature is in most cases a subjective opinion, we will consider a tool easy to use for learners (i.e., "Full Support") when a 'usability evaluation' with learners has been performed with a positive result for the authors.	0: No usability evaluation has been performed 1: Usability evaluation with MOOC learners has been performed with no positive results for the authors 2: Usability evaluation with MOOC learners has been performed with positive results for the authors

Implementation Score: There could be some systems that have considered some features during its design. However, the feature is not implemented in the real prototype yet. In this cases, we will provide the corresponding score in the template and will add an asterisk (*).

	[DE] DESIGN EXPRESSIVENESS							[PA] PRACTITIONERS' AFFORDABILITY AND ADOPTION						[LE] LEARNERS' EXPERIENCE		
	[REWARDS]		[CONDITIONS]				[ASSOCIATION]									
System	[DE1]	[DE2]	[DE3]	[DE4]	[DE5]	[DE6]	[DE7]	[DE8]	[PA1]	[PA2]	[PA3]	[PA4]	[PA5]	[PA6]	[PA7]	[LE1]	[LE2]	[LE3]
System N																		
Feature Score																		
Text Evidence																		
Comments																		

Appendix C

GamiTool-DM Type Lists

This appendix includes the list of resource types, action types, rule types and privilege types supported by the last version of GamiTool-DM. The identification of the different types has followed a four-step approach: (1) an empirical analysis of the resources supported by a set of different MOOC platforms (*e.g.*, Canvas Network, MiriadaX, Open edX, Moodle); (2) a literature review of the gamification conditions applied in previous MOOCs; (3) experience from the three co-designed empirical studies described in Chaper 3; and, (4) evaluations performed with MOOC practitioners and gamification designers within the context of this dissertation (see Chapter 4).

C.1 Resource Types

C.1.0. Platform *(default)*
C.1.1. Content Page
C.1.2. Discussion Forum
C.1.3. Quiz
C.1.4. Assignment
C.1.5. Peer Review
C.1.6. Wiki
C.1.7. File
C.1.8. External URL
C.1.9. External Tool
C.1.2. Video

C.2 Action Types

C.2.1. Log in
C.2.2. Log out
C.2.3. Invite a friend
C.2.4. Send message to student
C.2.5. Send message to group
C.2.6. Send message to instructor
C.2.7. Upload profile picture
C.2.8. Update profile information
C.2.9. Visit
C.2.10. Mark as done
C.2.11. Mark as read
C.2.12. Submit
C.2.13. Edit
C.2.14. Open
C.2.15. Participate
C.2.16. Post
C.2.17. Reply post
C.2.18. Give like
C.2.19. Give like to post
C.2.20. Give like to post reply
C.2.21. Receive like

C.2.22. Receive like in post

C.2.23. Receive like in post reply

C.2.24. Solve a question

C.2.25. Provide comment

C.2.26. Receive comment

C.2.27. Complete rubric

C.2.28. Watch

C.2.29. Rate

C.2.30. Receive a rating

Additional predefined actions could be added depending on the external tools considered beforehand. For instance, video-conference tools such as Zoom could involve actions such as *create meeting room*, *join meeting room*, etc.

C.3 Rule Types

C.3.1. Do the action itself

C.3.2. Do the action several times

C.3.3. Do the action before a specific date

C.3.4. Do the action between a specific time frame

C.3.5. Be one of the first participants doing the action

C.3.6. Get a score equal or higher than X

C.3.7. At least a % of X

C.3.8. Be ranked in the highest positions of the leaderboard

C.3.9. For a number of consecutive days

C.3.10. Get a score lower than X

Additional predefined rules could be added depending on the external tools considered beforehand. For instance, actions such as *join meeting room* could involve rules such as *stay in the room during certain time*, *stay in the room with X participants*, etc.

C.4 Privilege Types

C.4.1. Unlock resource
C.4.2. Unlock resource features
C.4.3. Become teacher assistant
C.4.4. Get extra attempts
C.4.5. Get extra time
C.4.6. Get extra points
C.4.7. Skip activity
C.4.8. Allow to pass with lower score
C.4.9. Extend deadline submission
C.4.10. Re-open activity
C.4.11. Join queue for instructors' feedback
C.4.12. Choose friend for group activity
C.4.13. Do different number of revisions
C.4.14. Get certificate discount
C.4.15. Submission reviewed by a different number of peers

Appendix D

GamiTool Screenshots

This appendix includes a set of GamiTool screenshots. Screenshots regarding the *Design & Development* subsystem involves the login page (Fig. D.1), the home page (Fig. D.2), the gamification design page (Fig. D.3 and Fig. D.4) and the reward configuration page (Fig. D.5). Screenshots regarding the *Enactment* subsystem involves the instructor analytics interface (Fig. D.6) and the student (Fig. D.7 and Fig. D.8) interface embedded in a Canvas and Moodle course respectively. A current version of the GamiTool system can be found in: *https://dev-gamitool.gsic.uva.es/*, last access: September, 2020. Additionally, the GamiTool source files can be downloaded from: *https://www.gsic.uva.es/gamitool/*, last access: September, 2020.

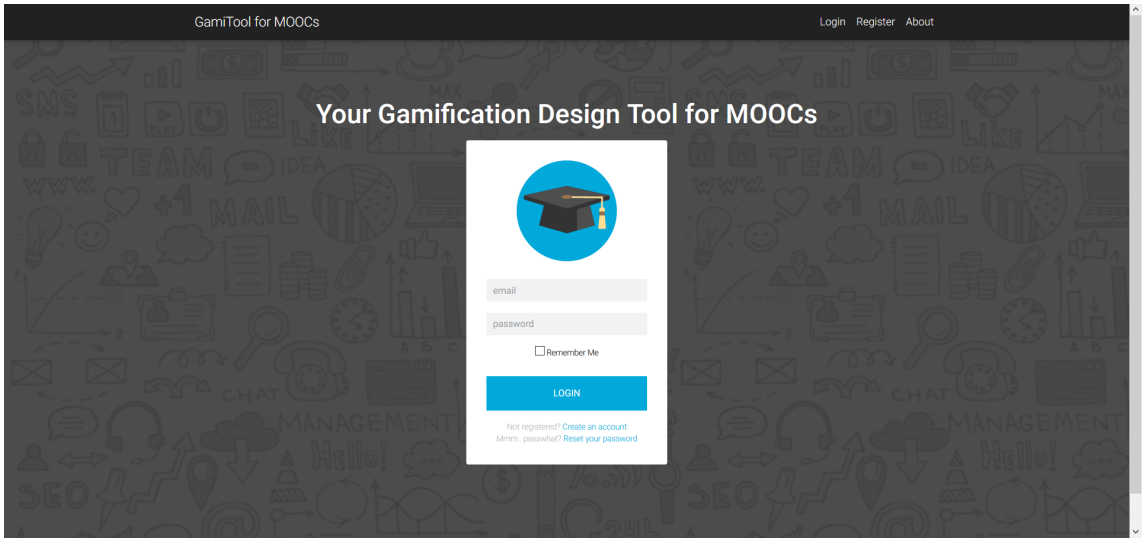


Figure D.1: GamiTool login page.

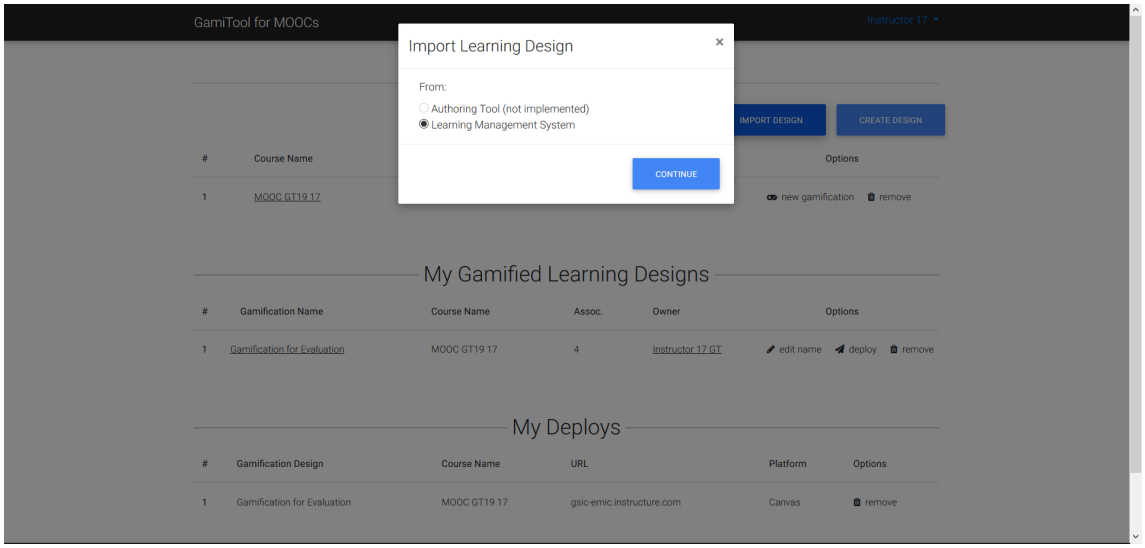


Figure D.2: GamiTool home page after clicking the import LD button.

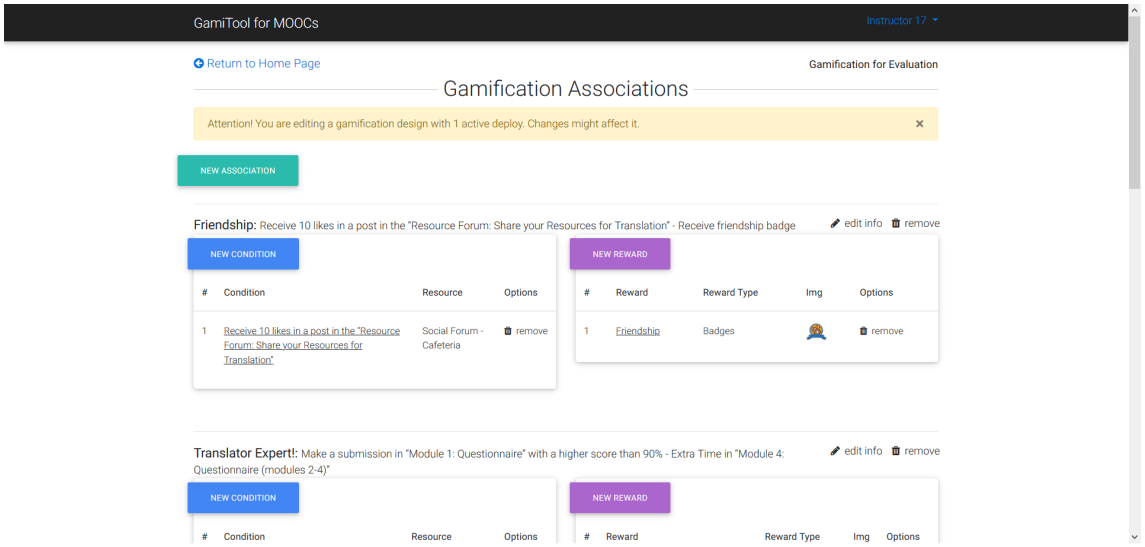


Figure D.3: GamiTool gamification page (associations section).

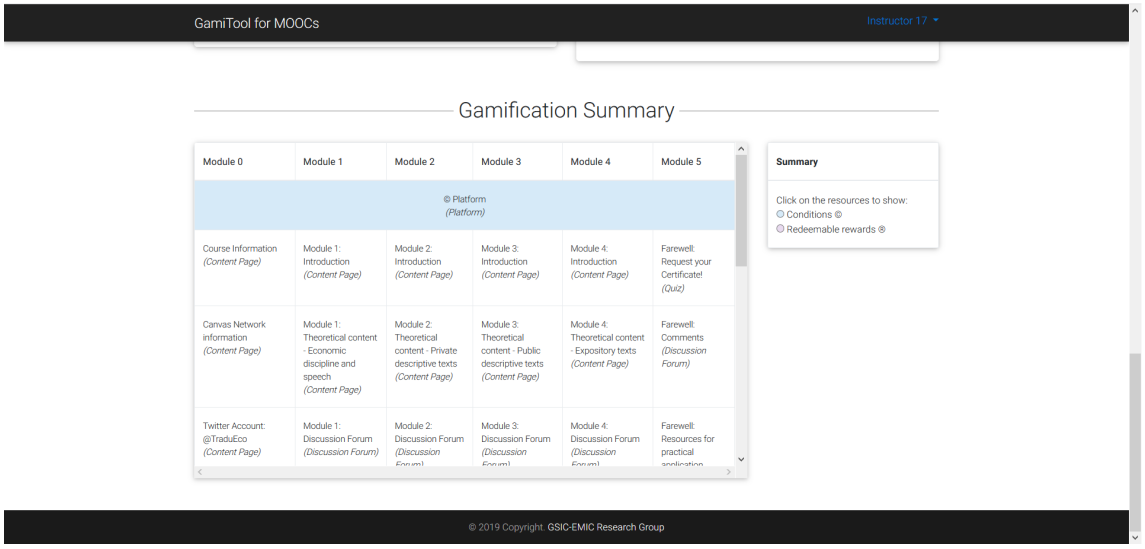


Figure D.4: GamiTool gamification page (summary section).

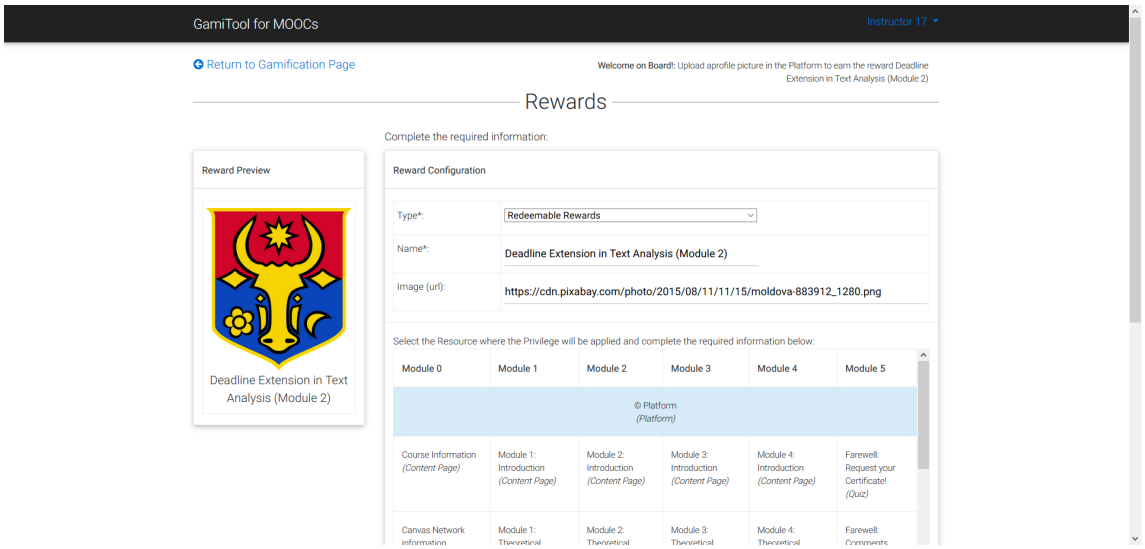


Figure D.5: GamiTool reward configuration page.

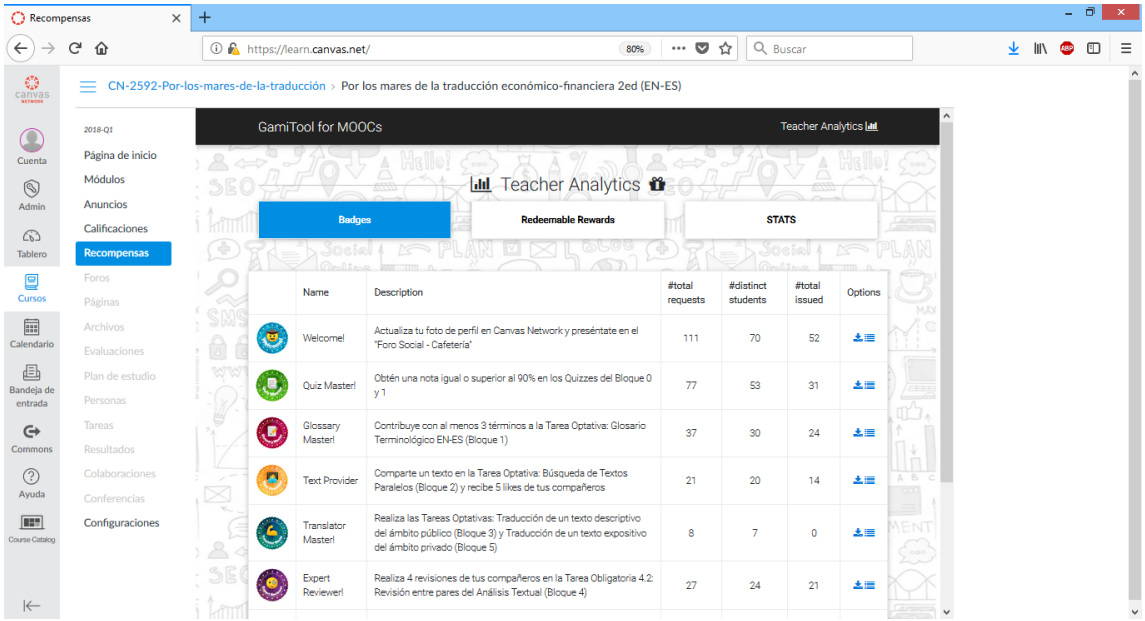


Figure D.6: GamiTool instructor page inserted in a Canvas Network MOOC.

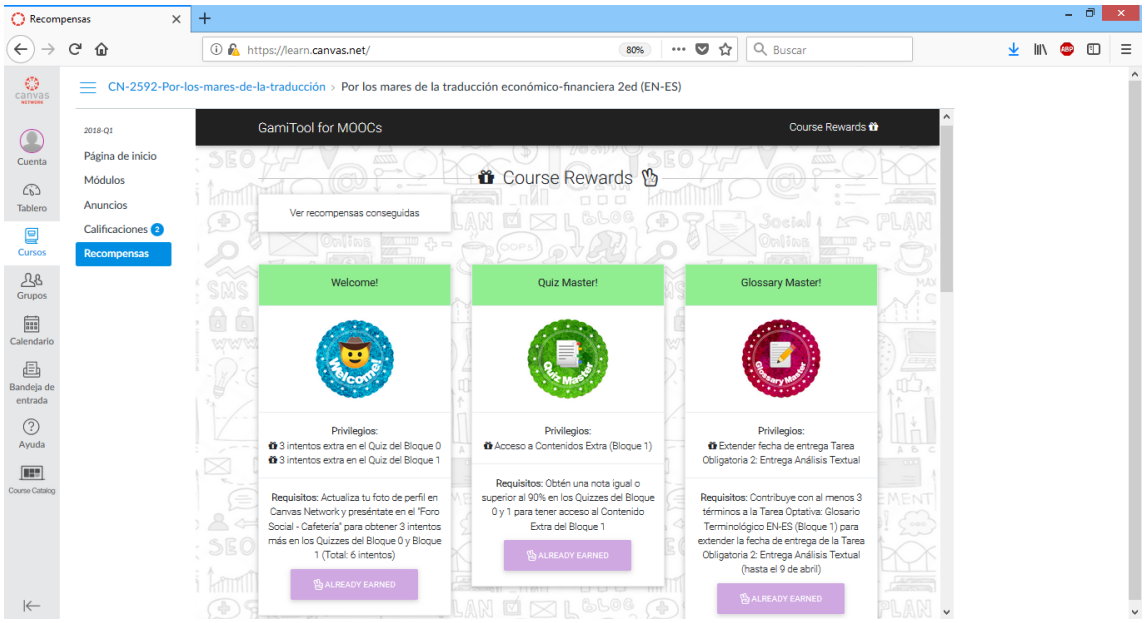


Figure D.7: GamiTool student page inserted in a Canvas Network MOOC.

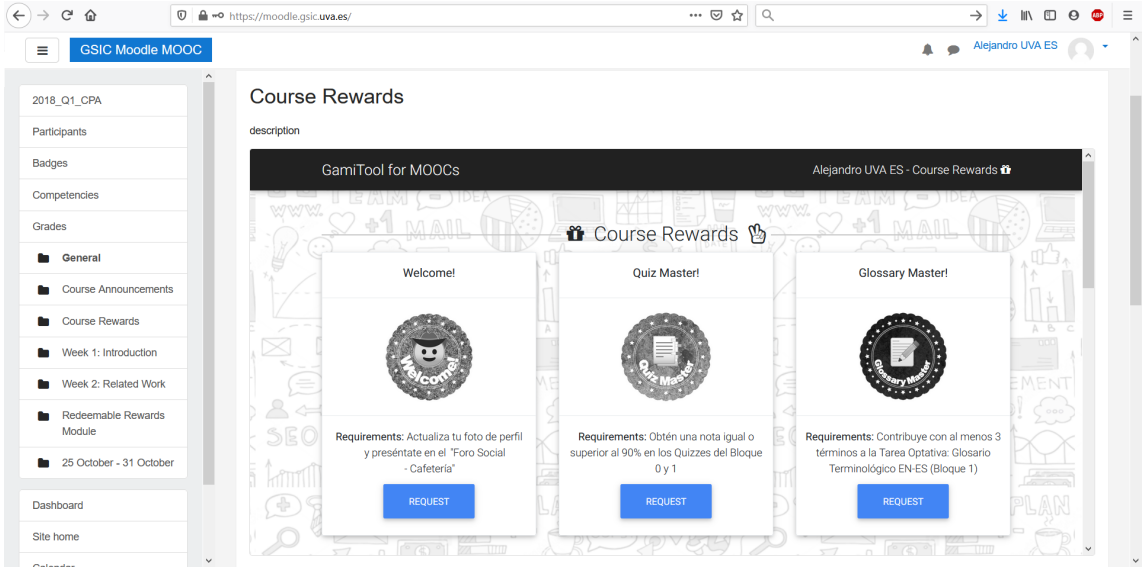


Figure D.8: GamiTool student page inserted in a Moodle MOOC.

Appendix E

GamiTool Evaluation Instrument

This appendix includes the evaluation worksheet of the second evaluation study of GamiTool, which contains contextual information, tasks descriptions, and the evaluation questionnaires. The worksheet was provided to the participants as a pdf document, although in face-to-face scenarios, it was also printed. The evaluation questionnaires were filled out online and sent back to the researcher. The evaluation tasks consisted on the design and instantiation of a given MOOC with GamiTool.

Dear participant,

We would like to first thank your participation in this evaluation. Before starting, we want to inform you about some important aspects of the evaluation (e.g., goal of this research, participant rights, evaluation tasks).

This evaluation is framed into Alejandro Ortega-Arranz PhD dissertation which aims to support practitioners (e.g., instructional designers, instructors, teachers, teaching assistants) with technological and conceptual tools for using gamification in MOOC environments. This PhD dissertation contributes to the development of the RESET Spanish Research Project which aimed to reformulate scalable educational ecosystems offering technological and pedagogical innovations (e.g., gamification). Further information about the project can be found at: *https://reset.gast.it.uc3m.es*. Therefore, the goal of this evaluation is to collect perceptions and opinions from MOOC practitioners about Alejandro's main contributions.

The data gathered in this evaluation (questionnaires answers, video and audio recordings, pictures, observations and created design artifacts) will be used with the only purpose of research by the University of Valladolid (anonymized data may be shared with other institutions for research purposes). This data will be stored and processed in devices and servers owned by the University of Valladolid and/or by the PhD candidate. Participants have the right of editing and removing partial or the full personal data gathered at any time by contacting the PhD candidate (*alex@gsic.uva.es*). The data gathered may be used anonymously for publication purposes. Keep in mind that this is a voluntary participation and you have the right to cancel the participation in this evaluation at any time without giving any reason.

The evaluation is expected to last 2 hours. Throughout this evaluation, you will be requested to *(1)* fill out a profiling questionnaire to contextualize your background; *(2)* read contextual information about the evaluation topic; *(3)* create a gamification design based on an existing MOOC design; *(4)* use GamiTool (the software tool that will be used during the evaluation) to deploy a gamified MOOC design; and *(5)* fill out a set of questionnaires to collect information about your personal opinion and experience with GamiTool. **This document contains all the questionnaires mentioned before, which are expected to be completed electronically using a pdf editor (e.g., Adobe Acrobat Reader). Once completed, please send the document back to the PhD candidate.**

This is a formative evaluation. Any comment, positive or negative, will be equally valuable. If you have any question during the evaluation, please do not hesitate to ask the researcher.

Again, thank you for participating in this evaluation!

I have read and understood the above information and have received answers to all my questions regarding this study.

I agree to participate.

Location and date:

Full name of participant:

Duplicate for participant

Dear participant,

We would like to first thank your participation in this evaluation. Before starting, we want to inform you about some important aspects of the evaluation (e.g., goal of this research, participant rights, evaluation tasks).

This evaluation is framed into Alejandro Ortega-Arranz PhD dissertation which aims to support practitioners (e.g., instructional designers, instructors, teachers, teaching assistants) with technological and conceptual tools for using gamification in MOOC environments. This PhD dissertation contributes to the development of the RESET Spanish Research Project which aimed to reformulate scalable educational ecosystems offering technological and pedagogical innovations (e.g., gamification). Further information about the project can be found at: *https:// reset.gast.it.uc3m.es*. Therefore, the goal of this evaluation is to collect perceptions and opinions from MOOC practitioners about Alejandro's main contributions.

The data gathered in this evaluation (questionnaires answers, video and audio recordings, pictures, observations and created design artifacts) will be used with the only purpose of research by the University of Valladolid (anonymized data may be shared with other institutions for research purposes). This data will be stored and processed in devices and servers owned by the University of Valladolid and/or by the PhD candidate. Participants have the right of editing and removing partial or the full personal data gathered at any time by contacting the PhD candidate (*alex@gsic.uva.es*). The data gathered may be used anonymously for publication purposes. Keep in mind that this is a voluntary participation and you have the right to cancel the participation in this evaluation at any time without giving any reason.

The evaluation is expected to last 2 hours. Throughout this evaluation, you will be requested to *(1)* fill out a profiling questionnaire to contextualize your background; *(2)* read contextual information about the evaluation topic; *(3)* create a gamification design based on an existing MOOC design; *(4)* use GamiTool (the software tool that will be used during the evaluation) to deploy a gamified MOOC design; and *(5)* fill out a set of questionnaires to collect information about your personal opinion and experience with GamiTool. **This document contains all the questionnaires mentioned before, which are expected to be completed electronically using a pdf editor (e.g., Adobe Acrobat Reader). Once completed, please send the document back to the PhD candidate.**

This is a formative evaluation. Any comment, positive or negative, will be equally valuable. If you have any question during the evaluation, please do not hesitate to ask the researcher.

Again, thank you for participating in this evaluation!

I have read and understood the above information and have received answers to all my questions regarding this study.

I agree to participate.

Location and date:

Full name of participant:

#Participant

[1/8] Profiling Quesionnaire (approx. 10m)

Some personal information:

Name:	
Age:	
Gender:	
Educational background:	
Current professional position and institution:	

Some open-ended questions about your teaching experience:

Years of experience in traditional education (face to face):	
Number of online courses (no MOOC) as practitioner:	
Number of MOOCs as practitioner (please, also indicate your role and platform):	

Rate your experience regarding:

Using computer-based software (not necessary as a teacher):

[Never | Almost never | Few times | Sometimes | A lot of times | Regularly]

Doing research on MOOCs:

[Never | Almost never | Few times | Sometimes | A lot of times | Regularly]

Using gamification in your classes/courses:

[Never | Almost never | Few times | Sometimes | A lot of times | Regularly]

If applicable, how much time did you dedicate to gamify your previous online courses?

Comments, clarifications and explanations:

Current Time (hh:mm)

[2/8] Contextual Information: Gamification in MOOCs (approx. 10m)

The goal of this document is to describe the context of this evaluation and to familiarize you with the gamification concepts that will be used throughout this evaluation. The presented information can be useful for both novice and expert practitioners and gamification designers to perform the incoming tasks. Please, read the document carefully and do not hesitate to ask the researcher in case of doubts.

Reasons for Gamification:

Gamification has shown promise to be effective in multiple educational domains regarding student motivation, engagement, interaction, participation and collaboration, among other benefits. Consequently, gamification is proposed to be used within MOOC environments addressing current MOOC problems such as the low student engagement and the high dropout rates.

Gamification Concepts:

Gamification is defined as the use of elements and structures that frequently appear in games (e.g., badges, customization, engagement loops) in non-game contexts (e.g., MOOCs). Gamifications can be classified according to the game elements and structures used. For example, *(i)* the elements related to scenarios and graphics that try to make a game-like experience (e.g., 3D virtual worlds); *(ii)* the elements related to user customization (e.g., avatars); or *(iii)* the elements related to rewards (e.g., trophies). In this evaluation, we will focus on the elements related to rewards that generate the so-called **reward-based gamifications**.

In this type of gamification, students are awarded with **rewards** (e.g., trophies) when pre-defined **conditions** (e.g., submit one quiz) are satisfied. Conditions can be associated with student peer approval, actions within the MOOC, group conditions, previous earned rewards, etc., depending on the **gamification intentions** that designers want to promote **(**e.g., increase student interaction).

In this research, we are also considering rewards associated to in-course privileges that students can attain and use during course runtime (e.g., earn an extra attempt in a quiz). In this evaluation, this type of rewards has been named as **redeemable rewards** as compared with other more **traditional rewards** (e.g., trophies) without real effect in the course progress. Finally, we will use the term **gamification association** for the association between a specific reward/s and a specific condition/s.

For example, the association “Reviewer Master!” *[Association 1]* might include a redeemable reward named “Resources for practical application” *[Reward 1]* that is issued when students complete the rubric of 4 different submissions in a peer review activity *[Condition 1]*. Through this association, students are encouraged to participate 4 times in this activity aiming to increase student participation and learning outcomes *[Gamification Intention]* by satisfying this association.

Please, rate the following statement:
I have understood all the gamification concepts presented in this section:

Strongly Disagree				Strongly Agree	
1	2	3	4	5	DK/NA

Comments, clarifications and explanations:

Current Time (hh:mm)

[3/8] Task 1: Create your Gamification Design (approx. 30m)

Imagine that you are the designer and instructor of a MOOC, in which you are considering the use of reward-based strategies. Create your gamification design for this MOOC following these steps:

1. Read and understand the purpose, activities and tools proposed for the MOOC. The structure and activity description of the MOOC is presented in **the next two pages**.
2. Add, at least, 3 more *Associations* as the one shown in the table below.

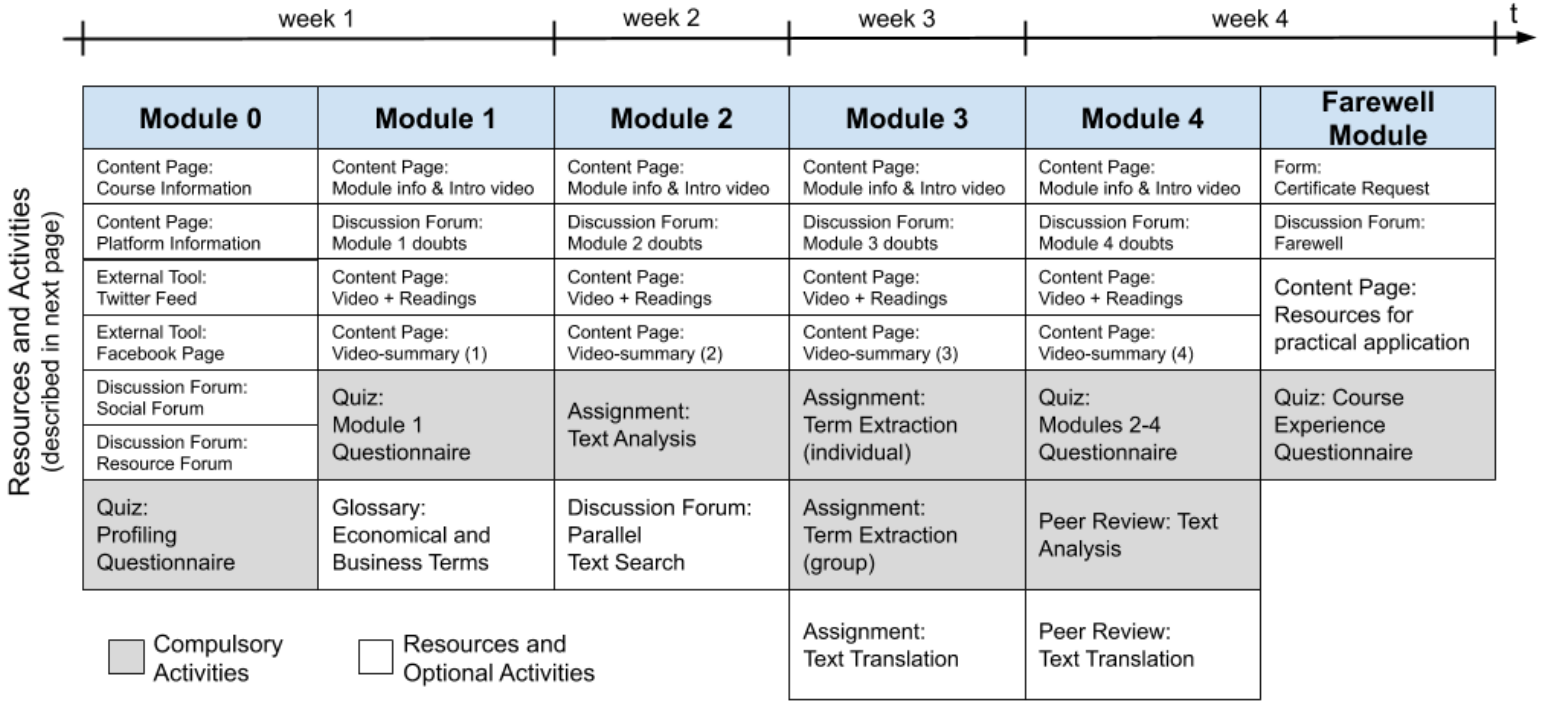
- Use traditional and/or redeemable rewards for your purposes.
- All associations can serve to the same gamification intention (e.g., promote student engagement), some of them to a concrete one (e.g., promote student interaction), or each one to a different one (e.g., submit a concrete task before a deadline).
- Clarifications and explanations can be added in the box below the table if needed. In this box you can also mention the difficulties faced while performing this task.

Assoc. Name	Gamification Intention	Condition/s	Reward/s
Reviewer Master!	By reading other peers' translations, students can learn different forms of translating the same text that they translated before, aiming to increase their learning outcomes.	Review 4 submissions in the "Peer Review: Text Analysis" activity (Module 4).	Redeemable Reward: Unlock the page "Resources for practical application" (Farewell Module).

Comments, clarifications and explanations:

MOOC Learning Design Real Example:

The following course is an adaptation of an instructor-led MOOC with 866 enrolled students in the last launched version (Ortega-Arranz, et al., 2019). The topic of the course is related to translation from English to Spanish in the business and economic fields, and the content has been adapted into 4 week-long modules (+2 extra modules including welcoming and farewell information). The modules included content pages with videos and recommended readings, discussion forums and individual and collaborative activities (see figure below). The activities were classified into compulsory and optional. Students had to submit all the compulsory activities in order to receive the course completion certificate. For all activities, the submission was due 8 days after the release of the activity. Remember that in this task you are performing the role of MOOC designer and instructor so you can modify the current learning design for your purposes.



Activity Description:

[Week 1] Module 0: Welcoming and general information of the course

- **Discussion Forum: Social Forum:** Participants are invited to share non-content-related comments.
- **Discussion Forum: Resource Forum:** Participants are invited to share materials useful for translation.
- **Quiz: Profiling Questionnaire:** Participants are requested to submit this profiling questionnaire to collect their preferences and background for task grouping and research purposes.

[Week 1] Module 1: Economic discipline and speech

- **Quiz: Module 1 Questionnaire:** Participants are requested to answer a 20-question questionnaire about the contents learned in Module 1. Participants must score 10/20 to pass the activity (2 attempts, 30min per attempt).
- **Glossary: Economical and Business Terms (optional):** Participants are invited to participate in a course glossary by submitting 3 terms (their translation, definition and source) related with the course topic. The glossary was implemented with Google Forms (submission) and Google Spreadsheets (view).

[Week 2] Module 2: Private descriptive texts in economy and business fields

- **Assignment: Text Analysis:** Participants are requested to do an analysis of an economical text according to the guidelines provided in the module videos. The analysis will be assessed in Module 4 through peer review following a given rubric.
- **Discussion Forum: Parallel Text Search (optional):** Participants are invited to share examples of private descriptive texts found during the daily life and comment their main sections.

[Week 3] Module 3: Public descriptive texts in economy and business fields

- **Assignment: Term Extraction (individual):** Participants are requested to identify and submit 10 frequent terms of economical texts found in a document provided by the instructor.
- **Assignment: Term Extraction (group):** Groups (5-6 participants) are requested to reach an agreement (in a group forum) and select and submit 20 frequent terms of public descriptive text.
- **Assignment: Text Translation (optional):** Participants are invited to translate a public descriptive text according to the guidelines provided in the module content.

[Week 4] Module 4: Expository texts in economy and business fields

- **Quiz: Modules 2-4 questionnaire:** Participants are requested to answer a 20-question questionnaire about the contents learned in Modules 2-4. Participants must score 10/20 to pass the activity (2 attempts, 30min per attempt).
- **Peer Review: Text Analysis:** Participants are requested to do 2 peer reviews of the "Assignment: Text Analysis" submitted in Module 2, following a given rubric for evaluation. Participants are invited to perform 2 more optional peer reviews.
- **Peer Review: Text Translation (optional):** Participants are invited to do 2 peer review of the optional "Assignment: Text Translation" submitted in Module 3, following a given rubric for evaluation.

[Week 4] Farewell Module: Farewell information

- **Form: Certificate Request (optional):** Participants are requested to provide personal information that will appear in the course certificate.
- **Discussion Forum: Farewell:** Participants are invited to comment their opinions about the course.
- **Content Page: Resources for practical application:** Participants are provided with extra materials and resources that can be useful for the practical application of the concepts learned in the course
- **Quiz: Course Experience Questionnaire:** Participants are requested to answer a 20-question questionnaire regarding their experience in the course for research purposes.

Current Time (hh:mm)

[4/8] Task 2: Deploy a Gamified MOOC Design (approx. 50m)

In this task, you will take the role of a MOOC instructor that wants to deploy (implement a learning design in the technological setting in which the design will be enacted) your gamified course (the one presented in the previous page) in a real MOOC platform without the support of researchers and/or technical staff. Please, deploy the given MOOC gamification design in a MOOC platform following the next steps:

1. Imagine that after long discussion with the other instructor of the course, you both have agreed to implement the following gamification association:

Assoc. Name	Gam. Intention	Condition	Reward
Welcome on board!	Encourage students to upload a profile picture to avoid impersonality in the course.	**Description:** Upload a profile picture in the Platform **Resource:** Platform **Action:** Upload a profile picture **Rule:** Do the action itself	**Type:** Redeemable Reward **Name:** Deadline Extension in "Module 2: Text Analysis" **URL:** image_url **Resource:** Module 2: Text Analysis (Assignment) **Privilege:** Deadline Extension until 23/02/2020

2. In order to design, deploy and enact the gamification design into your course, you will use the GamiTool software. GamiTool is a web-based system developed as part of Alejandro's PhD to allow MOOC practitioners to design, semi-automatically deploy and enact reward-based gamifications across multiple MOOC platforms. Please, follow carefully the instructions presented in the worksheet to carry out the task.

Worksheet for Task 2

1. Log in into Canvas Network

Log in into your MOOC hosted in a Canvas Network instance at *https://gsic-emic.instructure.com/*

Use the following credentials to access to the course as the main instructor of the MOOC:

- email: *evaluation_user@gamitool.com*
- password: *[-------]*

Enter in the course 'MOOC EVALUATION'.
Feel free to navigate in the course, and to understand and compare the paper-based learning design (see previous page) with the digital implemented version.

2. Log in into GamiTool

Open a new tab in your browser and log in into the GamiTool platform at *https://dev-gamitool.gsic.uva.es/* by using the same credentials as before. Once you have successfully log in into the platform, you will be redirected to the *Home Page*. The Home Page shows a summary of the non-gamified (top), the gamified (middle) and deployed (bottom) learning designs in your GamiTool account.

3. Upload your course design to GamiTool

Click the '*Import Design*' button in the Home Page, select the *"Learning Management System"* option, click the *'Continue'* button and complete the required information.

- *'Site':* the url of the MOOC platform (i.e., gsic-emic.instructure.com).
- *'Bearer':* a token that will allow GamiTool to connect with the MOOC platform. To get your Canvas bearer, switch to the browser tab in which the Canvas course is open. In Canvas Network, once you are logged in, instructor's bearer can be generated on the left panel > Account > Settings > (scroll down) +New Access Token (see Figure 1). Provide the name 'GamiTool' as the purpose of the token, leave blank the expiration date and 'generate' the token. Copy and paste the generated token into the "Bearer" box in GamiTool.

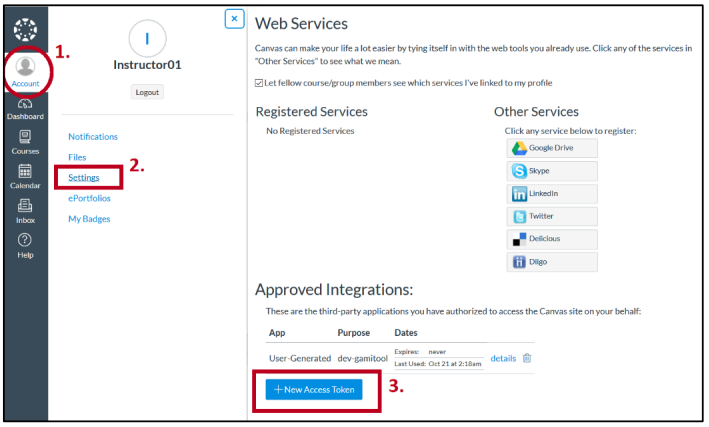


Figure 1. Steps for creating a new bearer token in Canvas.

After connecting with the Canvas platform, select the course that you want to import in GamiTool, in this case *'MOOC EVALUATION'* to retrieve the course contents and resources into GamiTool (this process can take up to a minute) and press the 'Import' button.

If the import process was successfully carried out, a small window will pop up asking you whether import another course or return to the *'Home Page'*. Since you want to gamify only this course, press the *'Go to Home Page'* button. GamiTool has now copied the LD of the course into your GamiTool account so you can gamify it according to your purposes.

4. Create a new gamification design

Add a new gamification to the imported course by clicking the '*New gamification'* option, and name it '*Gamification for Evaluation*'. You will be redirected to the *Gamification Page* with a blank gamification (i.e. without gamification associations). Through this interface, you will be able to add *gamification associations* and see the status of your *gamification summary* on the bottom side of the page.

5. Create a new association and add conditions and rewards

Create a new *gamification* association by clicking the *'New Association'* button. GamiTool will ask you for a *'visible name'* (name of the association that students can claim) and *'visible description'* (description of the association). For this concrete association (see grey Table before),

- *'visible name'*: the association name (e.g., Welcome on Board!).
- *'visible description'*: Condition description + "to earn the reward" + Reward name (e.g., Upload a profile picture in the Platform to earn the reward Deadline Extension in Text Analysis (Module 2)).
- Click the *'Create Association'* button to create the Association.

Add a condition to the new created association by clicking the *'New Condition'* button inside the 'Welcome on Board!' association. For this concrete association,

- *'description'*: the description of the condition (e.g., Upload a profile picture in the Platform).
- *'resource'*: click the resource in the Learning Design of the course where the condition will be applied (e.g., Platform).
- *'action'*: the action that students should perform within the selected resource (e.g., Upload profile picture).
- *'rule'*: the concrete rule that students should perform within this action (e.g., Do the action itself).
- Click the *'Save Condition'* button to save the Condition.

Add a reward to the new created association by clicking the *'New Reward'* button inside the *'Welcome on Board!'* association. For this concrete association,

- *'reward type'*: the reward type (e.g., Redeemable Reward).
- *'name'*: name of the reward (e.g., Deadline Extension in Text Analysis (Module 2)).
- *'image (url)'*: the url image of the reward (e.g., https://cdn.pixabay.com/photo/2015/08/11/11/15/moldova-883912_1280.png)
- *'resource privilege'*: click the resource in the LD where the redeemable reward will be applied (e.g., Assignment: Text Analysis" (Module 2)).
- *'privilege'*: the privilege itself based on the type of resource selected (e.g., Deadline Extension).
- *'new deadline'*: the new deadline for the selected resource (e.g., 25/12/2019)

- Click the *'Save Reward'* button to save the Reward.

Congratulations! You have already configured the first gamification association of your gamified MOOC design. However, gamification designs usually have several association. Now, complete the gamification design by configuring the next 3 associations following the steps as before:

Assoc. Name	Gam. Intention	Condition	Reward
Reviewer Master!	By reading other peers' translations, students can learn different forms of translating the same text that they translated, thus increasing their learning opportunities.	**Description:** Submit 4 revisions in "Module 4: Peer Review of Text Analysis" **Resource:** Module 4: Peer Review of Text Analysis **Action:** Submit **Rule:** Do the action several times: 4	**Type:** Redeemable Reward **Name:** Instructor Revision in "Module 4: Peer Review of Text Analysis" **URL:** image url **Resource:** Module 4: Peer Review of Text Analysis **Privilege:** Receive feedback from instructors (Instructor Revision)
Translator Expert!	Learners are expected to achieve a high score in the first quiz by putting more attention to the course videos and readings.	**Description:** Make a submission in "Module 1: Questionnaire" with a higher score than 90% **Resource:** Module 1: Questionnaire **Action:** Submit **Rule:** Get a score equal or higher than: 90%	**Type:** Redeemable Reward **Name:** Extra Time in "Module 4: Questionnaire (modules 2-4)" **URL:** image url **Resource:** Module 4: Questionnaire (modules 2-4) **Privilege:** Extra Time: 10min
Friendship	Encourage student participation in the "Resource Forum" to interact with other course peers	**Description:** Receive 10 likes in a post in the "Resource Forum: Share your Resources for Translation" **Resource:** Resource Forum: Share your Resources for Translation **Action:** Receive Like in an entry **Rule:** Do the action several times: 10	**Type:** Badge **Name:** Friendship **URL:** image url **Badge Suite:** No

6. Deploy your gamified learning design

Once you finished configuring all the gamification associations, go back to the home page by clicking the *"Return to Home Page"* button presented in the top left corner of the *'Associations'* Page.

In the *'Home Page'*, click the '*Deploy*' button () of the created gamified learning design. In this case, since we want to deploy this gamification design into the same course that we imported, select the 'Same course' option of the window, and press the *'Confirm'* button.

When deploying, GamiTool creates a section named 'GamiTool' in the MOOC where students can access to the configured rewards and teachers can orchestrate the progress of such rewards.

7. Preview the results

Switch to the Canvas tab in your browser and go to the main page of your course: Canvas > *Courses* > *MOOC EVALUAT.* Preview the results from both the instructor and student perspectives as described below:

- From the instructor view (click the 'GamiTool' tab on the left panel, see Fig. 2) you will be able to see some analytics of gamification during course runtime and perform those redeemable rewards that require instructors' intervention (e.g., instructor revision).

- Go to the student view by clicking '*Home'* in the left white panel (see Fig. 2), then, in the right panel, click the '*Student View*'. Students will see in the 'GamiTool' section of the course the requirements to earn the rewards and the buttons to claim them. NOTE: zoom in/out in the GamiTool section to better view the course rewards (if necessary).

  Try to earn the 'Translator Expert' reward. NOTE: Before claiming, check the time for completing Quiz Modules2-4 (Module 4): 30min. Once earned, the privilege should be automatically applied: 40min.

Assoc. Name	Gam. Intention	Condition	Reward
Translator Expert!	Learners are expected to achieve a high score in the first quiz by putting more attention to the course videos and readings.	**Description:** Make a submission in "Quiz: Module 1 questionnaire" (Module 1) with a higher score than 90% **Resource:** "Quiz: Module 1 questionnaire" (Module 1) **Action:** Submit **Rule:** Get a higher score than: 90	**Type:** Redeemable Reward **Name:** Extra Time in Quiz (Module 4) **URL:** image url **Resource:** Quiz Modules 2-4 (Module 4) **Privilege:** Extra Time, 10min

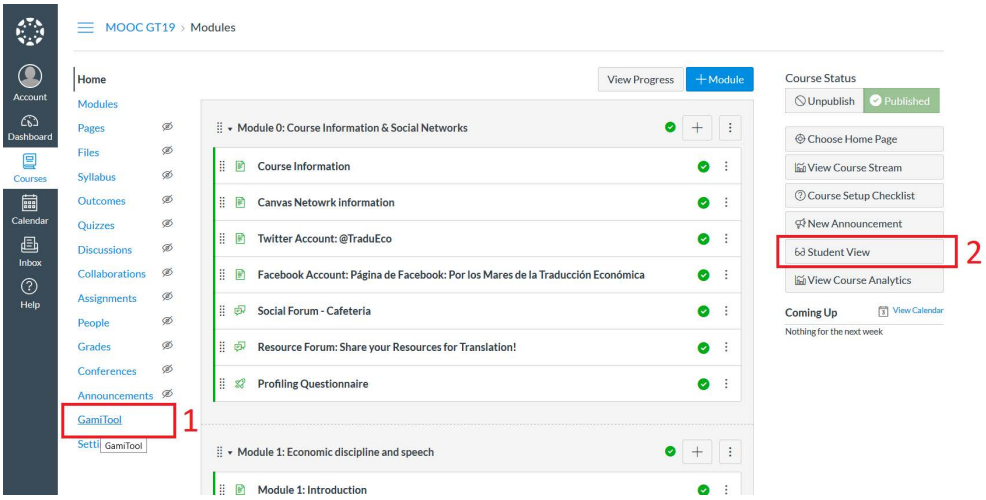
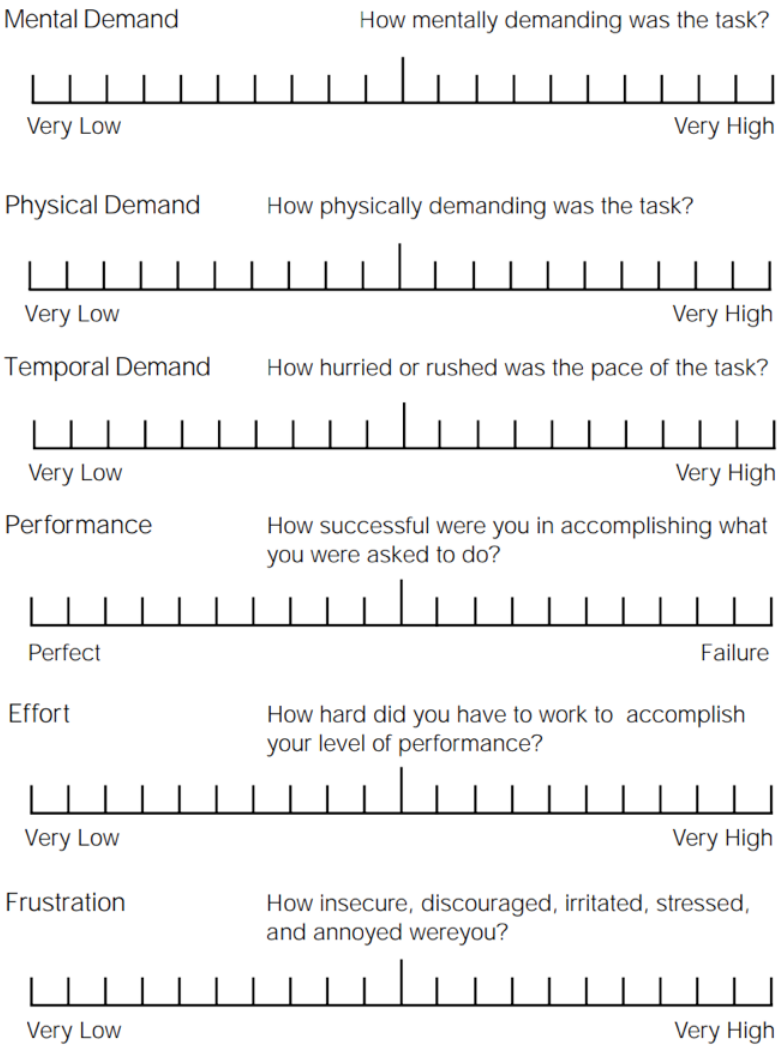


Figure 2. Steps to preview the results: (1) Instructors' view, (2) students' view.

Current Time (hh:mm)

[5/8] Questionnaire A (approx. 5m)

This is a standard questionnaire that measures the workload of a task[1]. Please, fill the boxes that best expresses how you feel about each statement after using GamiTool for deploying a given gamified learning design (Task 2):



Comments, clarifications and explanations:

[1] This questionnaire is based on the NASA Task Load Index (NASA-TLX), which was developed by the Human Performance Group at NASA's Ames Research Center.

[6/8] Questionnaire B (approx. 5m)

This is a standard questionnaire that measures the overall usability of a system[2]. Please select the answer that best expresses how you feel about each statement after using GamiTool today (Task 2):

	Strongly Disagree				Strongly Agree
	1	**2**	**3**	**4**	**5**
1. I think I would like to use GamiTool frequently.	☐	☐	☐	☐	☐
2. I found GamiTool unnecessarily complex.	☐	☐	☐	☐	☐
3. I thought GamiTool was easy to use.	☐	☐	☐	☐	☐
4. I think that I would need the support of a technical person to be able to use GamiTool.	☐	☐	☐	☐	☐
5. I found the various functions in GamiTool were well integrated.	☐	☐	☐	☐	☐
6. I thought there was too much inconsistency in GamiTool.	☐	☐	☐	☐	☐
7. I would imagine that most people would learn to use GamiTool very quickly.	☐	☐	☐	☐	☐
8. I found GamiTool very awkward to use.	☐	☐	☐	☐	☐
9. I felt very confident using GamiTool.	☐	☐	☐	☐	☐
10. I needed to learn a lot of things before I could get going with GamiTool.	☐	☐	☐	☐	☐

How likely are you to recommend GamiTool to others in case of using gamification in MOOCs?

Not at all likely 0 1 2 3 4 5 6 7 8 9 10 Extremely likely

Comments, clarifications and explanations:

[2] This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation. © Digital Equipment Corporation, 1986.

Current Time (hh:mm)

[7/8] Task 3 [optional] Gamify your own MOOC (approx. 20m)

Congratulations for your contribution to this evaluation and thank you for participating in this optional task! Now is time for you to digitally represent and re-deploy the gamification design that you created in Task 1. To do so, edit the gamified learning design created in Task 2 and add as many associations created in Task 1 as you desire. You don't need to deploy the course again, just refresh your Canvas course to see the new associations in your design. If you succeed, congratulations! you have gone from the conceptualization to the deployment of a gamified MOOC learning design in this workshop.

Current Time (hh:mm)

[8/8] Questionnaire C (approx. 10m)

This is a short questionnaire created by GSIC-EMIC to collect opinions and perceptions from GamiTool users. Please, circle the answer that best expresses how you feel about each statement after using GamiTool today:

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 intentions:

Strongly Disagree				Strongly Agree	
1	2	3	4	5	DK/NA

Further comments

I think GamiTool allows the design and deployment of gamified activities performed in tools that I frequently used in MOOCs (e.g., discussion forums, quizzes):

Strongly Disagree				Strongly Agree	
1	2	3	4	5	DK/NA

Further comments

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:

Strongly Disagree				Strongly Agree	
1	2	3	4	5	DK/NA

Further comments

I think Redeemable Rewards (e.g., extend a quiz deadline) can be more engaging than Traditional Rewards (e.g., badge) in MOOC environments.

Strongly Disagree				Strongly Agree	
1	2	3	4	5	DK/NA

Further comments

What did you like most from GamiTool? *(write as many statements as you consider)*

What did you like least from GamiTool? *(write as many statements as you consider)*

Comments and clarifications:

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