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Supporting Teachers in the Gamification Process of Learning Situations

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Resumen del TFM

La inclusión de elementos típicos de los videojuegos en entornos de aprendizaje (i.e. gamificación) está actualmente reportanto beneficios educativos como el aumento de la motivación e involucración de los estudiantes en la realización de actividades de aprendizaje. Dada la dificultad de los docentes para la creación de situaciones de aprendizaje gamificadas, algunos autores han propuesto herramientas de autoría que permiten gamificar situaciones de aprendizaje. Sin embargo, actualmente existe un salto entre los sistemas propuestos para la creación de actividades gamificadas y las herramientas existentes que típicamente usan los docentes, como son entornos de aprendizaje virtual (VLEs) (e.g. Moodle), herramientas Web 2.0 (e.g. Google Drive), clientes móviles de realidad aumentada (e.g. Junaio), o globos terráqueos virtuales 3D (e.g. Google Earth). Por eso, este Trabajo Fin de Máster pretende ayudar a los profesores en el proceso de creación de situaciones de aprendizaje gamificadas. Para ello: (i) Se explora la literatura existente sobre gamificación; (ii) Se propone una arquitectura y un modelo de datos que permita la creación de situaciones gamificadas formadas por herramientas existentes de los tipos señalados (VLEs, herramientas Web 2.0, clientes móviles RA, globos terráqueos virtuales 3D); (iii) Se desarrolla un prototipo que implementa la arquitectura y el modelo de datos propuestos; (iv) Se realiza una prueba de concepto del prototipo. Como base para el trabajo, se parte del sistema GLUEPS-AR. Este sistema permite completar el diseño educativo y desplegar situaciones de aprendizaje con las características descritas previamente, pero su capacidad de gamificación es limitada.

Palabras clave

Gamificación, Elementos de Diseño de Juegos, Plataforma de Gamificación, Situaciones de Aprendizaje, Multiples Espacios, Profesores.

Abstract

During the last years, the addition of game design elements in learning contexts (i.e. gamification) is reporting different educational benefits, such as the raise of students' motivation and engagement while perform gamified activities. However, it is not a trivial task to gamify learning activities for non-expert teachers. Therefore, some authors have proposed different authoring tools in order to alleviate this burden. Nowadays, there is a significant difference between these proposed tools and the current typical platforms used by the teachers, such as virtual learning environments (VLEs) (e.g. Moodle), Web 2.0 frameworks (e.g. Google Drive), augmented reality (AR) mobile clients (e.g. Junaio), or 3D virtual globes (e.g. Google Earth). Thus, this Master Thesis addresses this problem by aiming a system able to help teachers in the gamification process of learning situations. To carry this out, this dissertation presents the following contributions: (i) A description of the state-of-the-art related to the gamification process; (ii) A proposal of an architecture and a data model that allow the creation of gamified learning situations using the currently used platforms (VLEs, Web 2.0 frameworks, AR mobile clients, 3D virtual globes); (iii) The development of a prototype that implements the mentioned architecture and data model; and (iv) The evaluation of this prototype. We will use the GLUEPS-AR system as the starting point to develop our work. Currently, this system allows to complete the design of learning situations, involving different kinds of physical and virtual spaces, and platforms like the ones previously described. Nevertheless, this system was not designed to carry out gamification processes and thus, its gamification capabilities are limited.

Keywords

Gamification, Game Design Elements, Gamification Platform, Learning Situations, Multiple Spaces, Teachers.

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Chapter 1

Introduction

Resumen: Este capítulo describe de forma resumida el contexto, la motivación, los objetivos, y la metodología de este Trabajo Fin de Master (TFM): Los videojuegos son capaces de transmitir sensaciones a los jugadores (p.ej. tensión o diversión), fomentando su consumo e interacción. La gamificación consiste en abstraer los elementos de los videojuegos que producen estas sensaciones e incluirlos en otros contextos. Concretamente, en el contexto de la educación se ha demostrado que la gamificación puede afectar entre otros aspectos, a los resultados de aprendizaje, al comportamiento, a la motivación, y a la involucración de los estudiantes cuando realizan una actividad. Debido a la evolución de la tecnología, las actividades de aprendizaje de hoy en día pueden involucrar entornos de aprendizaje virtuales, herramientas de terceros y diferentes tipos de espacios[1]. Sin embargo, actualmente no existe una propuesta que permita gamificar situaciones de aprendizaje con estas características. Por eso, consideramos que existe un salto entre estas herramientas frecuentemente utilizadas en educación y los sistemas existentes capaces de gamificar actividades de aprendizaje. Como consecuencia, el objetivo principal que se propone alcanzar (ver Fig. 1.2) es: *"Ayudar a los profesores a crear situaciones de aprendizaje gamificadas que pueden incluir recursos y herramientas comunes en educación y que pueden involucrar diferentes espacios físicos y virtuales"*. Para conseguir tal objetivo, la metodología utilizada en este trabajo ha sido la conocida como "Método de Ingeniería", realizando finalmente una prueba de concepto con un prototipo desarrollado.

1.1 Introduction

Videogames are interactive activities able to rise up player's feelings (e.g. excitement, fun, etc.) through challenges, competitions, and many other factors. Over the last years, videogames are considered as the main genre of entertainment (Domínguez et al., 2013). One of the reasons of the popularity of videogames is that people are more likely to spend their time and effort in activities that produce such feelings (Fitz-Walter, 2015). Thus,

[1]Espacio: entorno dimensional en el que existen objetos y ocurren eventos que tienen posición y dirección dentro de tal entorno(Muñoz-Cristóbal et al., 2013).

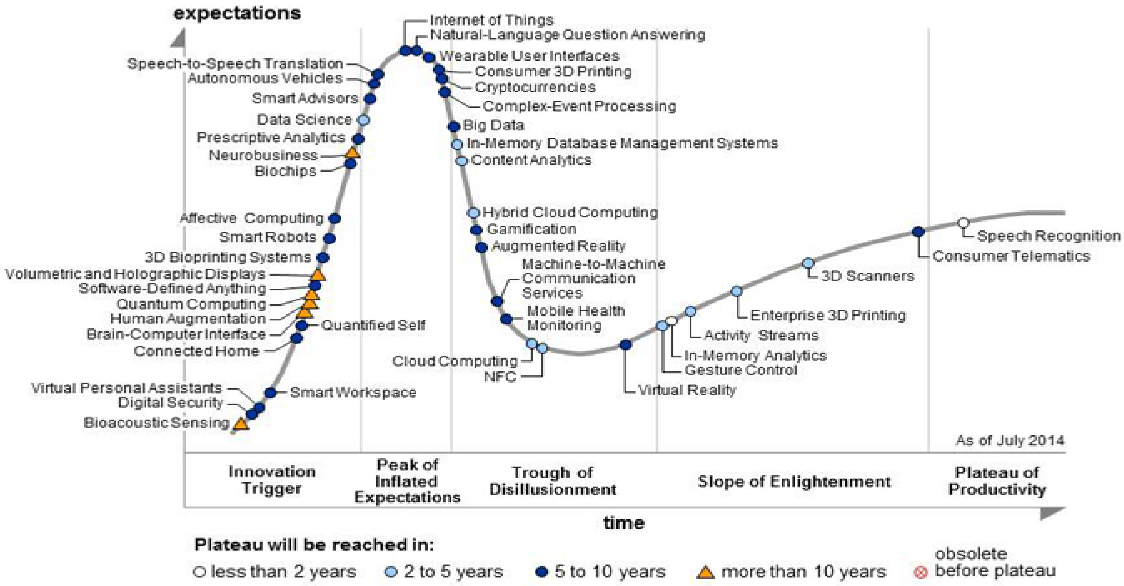

Figure 1.1: Gartner hype cycle for 2014.

some researchers started to study the possible benefits of using videogames in learning environments (e.g. increase students' engagement). Finally, these studies led to a new discipline known as Digital Game-Based Learning (DGBL) (Prensky, 2001).

Some years later, similar to DGBL, a new trend related to the concepts of "videogames" and "engagement" started to appear: the so-called Gamification. The term "gamification" was originally coined by N. Pelling for the business field in 2002 (Marczewski, 2013). Pelling referred to gamification as putting together the game design elements (i.e. competitiveness, targets, rewards and recognitions) in everyday business activities (Shenmar, 2014). The term started to be generally adopted since 2010, when it was employed at conferences (Xu, 2011), started to appear in books (Zichermann & Cunningham, 2011), in commercial gamification platforms (Bunchball, 2010), and was integrated to the Gartner's hype cycle in 2011 (Fig. 1.1 shows the current status).

Nowadays, gamification is defined as the use of game design elements in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011). The aim of gamification is to identify the game elements and features that make videogames enjoyable and fun to play (i.e. game design elements), and adapt them to be included in non-game contexts (Simões, Redondo, & Vilas, 2013) such as business, marketing, health or wellness initiatives (Dicheva, Dichev, Agre, & Angelova, 2015).

Education is another non-game context where gamification can be applied. Gamification in education (gamification, from now on) has the property of using game design elements that make people get engaged without using any specific game (Simões et al., 2013). Thus, unlike GBL which aims to include learning content into the game elements, gamification refers to the inclusion of game content into the learning activities. Previous studies have concluded that gamification can affect to the students' learning outcomes (Arnab et al., 2014), behavior (Hakulinen, Auvinen, & Korhonen, 2013), socialization

(De Sousa Borges, Durelli, Reis, & Isotani, 2014), intrinsic motivation[2] (Suh, Wagner, & Liu, 2015), extrinsic motivation[3] (Suh et al., 2015), and finally, engagement (Muntean, 2011). Hence, teachers can take advantage of these potential benefits including game design elements and common features of videogames into their own learning situations.

1.2 Motivation and Problem Description

Due to the rapid evolution of technologies, specially in mobile phones, current learning situations may involve different spaces[4] (i.e. physical and virtual spaces) and virtual resources physically positioned (i.e. Augmented Reality); may include third-party provider tools which are frequently used in education (e.g. Google Docs); and can be deployed in different virtual learning environments (VLEs) (e.g. Moodle) (Muñoz-Cristóbal et al., 2013). The literature on this field shows different examples of ad-hoc gamified educational activities that include some of the aforementioned features. For instance, Fitz-Walter, Tjondronegoro, and Wyeth (2011) gamified an educational activity that involved both physical and virtual spaces; and Domínguez et al. (2013) gamified a learning situation deployed in a VLE (i.e. Blackboard[5]) whose activities were associated to documents and spreadsheets.

These gamified activities were specifically programmed to fit the situation to which they would be applied. However, most teachers have no programming knowledge, so if they want to create their own gamified learning situations, they have to be helped by programmers. Thus, some authors and companies have proposed and developed digital platforms (i.e. gamification platforms) which provide a graphical interface to help teachers gamify learning situations. Nevertheless, existing gamification platforms present some limitations in the kind of learning situations they are able to implement, in the game design elements they are able to include, or both.

For example, Dicheva, Irwin, Dichev, and Talasila (2014) and Simões et al. (2013) proposed systems able to gamify different kinds of activities limited to the virtual space. The systems proposed by Ternier, Klemke, Kalz, Van Ulzen, and Specht (2012) and Gagnon (2010) permit the creation of learning situations that may involve physical and virtual spaces, but the game mechanics they are able to implement and the activities they are able to deploy are limited. There are also gamification platforms (e.g. Captain Up[6]) that can be adapted to educational purposes implemented in VLEs. However, actions performed in these platforms are limited to web-student interactions and cannot gamify third-party tools.

[2]Intrinsic motivation is considered as the inherent satisfaction that an activity can produce such as interest or enjoyment (Ryan & Deci, 2000).

[3]Extrinsic motivation is a construct that created whenever an activity is done in order to attain some separable outcome such as external prods, pressures or rewards (Ryan & Deci, 2000).

[4]Space: dimensional environment in which objects and events occur, and in which they have relative position and direction(Muñoz-Cristóbal et al., 2013).

[5]*http://www.blackboard.com/* [last access: July 2015].

[6]*https://captainup.com/* [lass access: July 2015].

These previous systems have been proposed and developed to help teachers gamify their own learning situations. However, they are not able to gamify activities that could involve the capabilities commonly used in nowadays learning situations. Thus, we believe that there is still a gap between the existing gamification systems and the tools frequently used in learning environments such as VLEs (e.g. Moodle), Web 2.0 tools (e.g. Google Spreadsheets), Augmented Reality (AR) mobile clients (e.g. Junaio) and 3D Virtual Globes (3DVG) (e.g. Google Earth). Teachers could take advantage, when gamifying their own learning situations, of a gamification platform that could help them to design and deploy gamified learning situations. And therefore, they could apply the benefits of gamification into their own learning situations without learning programing knowledge nor programmers help.

1.3 Objectives

Once the research context of this Master Thesis has been exposed, we can propose the main goal of this dissertation:

"To help teachers create gamified learning situations that can make use of resources and tools frequently used in education and that may involve different physical and virtual spaces".

This main goal can be achieved through the following secondary objectives:

1. **To model the lifecycle of gamified learning situations:** Some authors have defined and described the different phases that shape the lifecycle of learning situations without gamification components. The inclusion of game design elements in learning situations can alter these phases. Therefore, modeling the phases of gamified learning situations will help to identify which elements and actions should be included and performed in each stage to achieve a right gamification behavior. Additionally, this model will help to determine how teachers can be assisted when creating such gamified learning situations.

2. **To automate, in the enactment phase, the gamification components included within learning situations:** During the enactment phase of a gamified learning situation, students perform the activities that compose the situation. The achievement of the educational goals depends, among other factors, on the students' actions within the activities. One of the most used gamification mechanisms is to virtually reward students' actions that are supposed to be beneficial, expecting that this will help to achieve the educational goals of the activities (e.g. using points or badges). Such recognition can be performed at any time during the learning situation (from real-time rewarding to reward at the end of the learning situation). However, real-time rewarding can provide students with real-time feedback which could let them know their progress while performing the actions. A model based on the manual rewarding by the teacher can imply excessive work for them. It might also increase

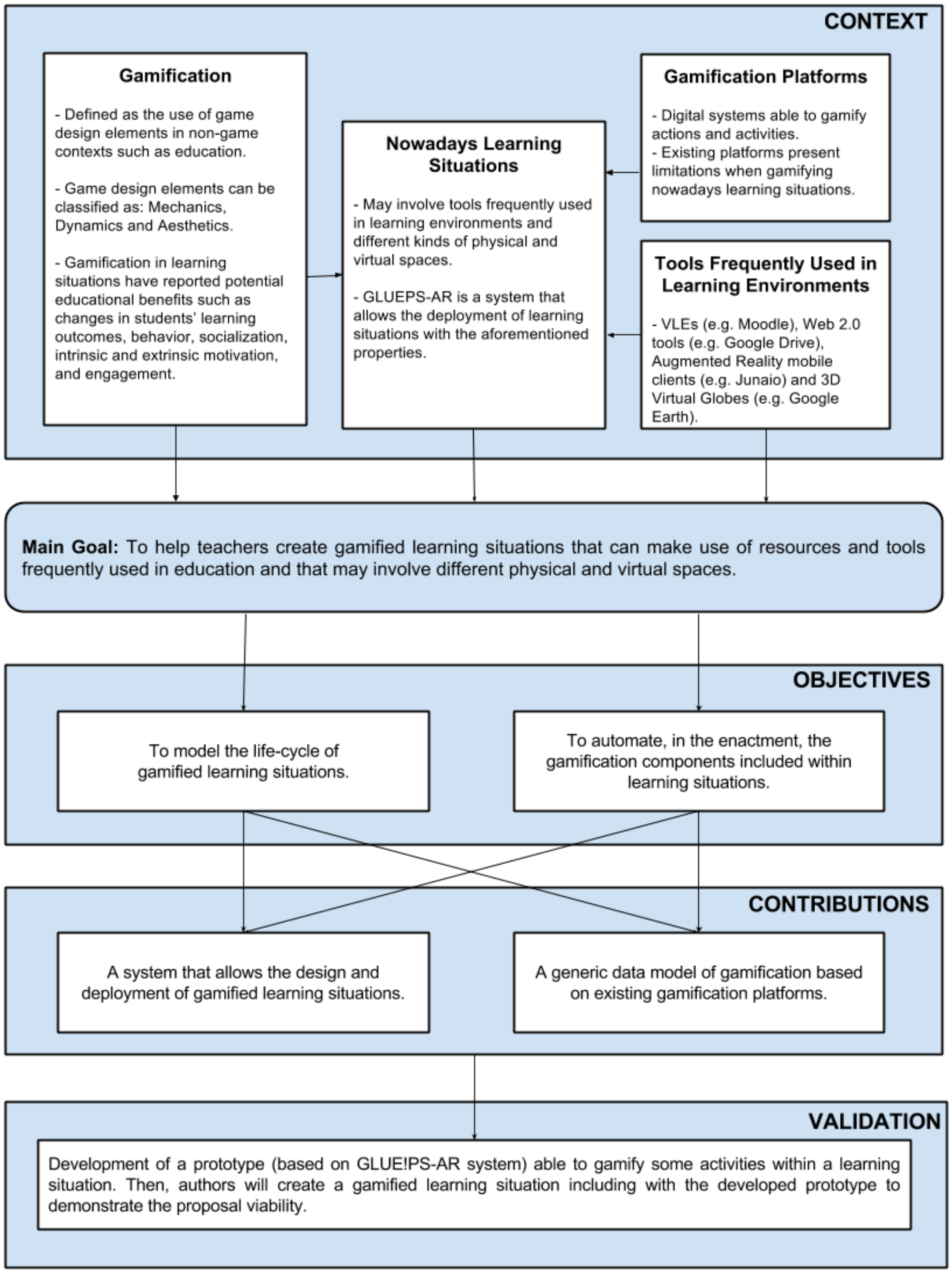

Figure 1.2: General schema of the dissertation including its context, the aimed objectives, the original contribution and the evaluation.

the rewarding latency, since teachers would have to monitor each student. On the contrary, an automatized reward system could allow to provide students with real-time recognition. To carry out this automatic rewarding process, the architectural components that would implement this functionality have to be analyzed as they should be deployed when creating gamified learning situations. Thus, the second goal of this dissertation is to analyze these gamification components, integrate them in an architecture that supports the creation of gamified learning situations and let teachers configure them.

The context, the main and secondary goals, the contributions of this dissertation and a prototype evaluation are sketched in Fig. 1.2.

1.4 Methodology

The main goal of this dissertation is to help teachers create gamified learning situations by means of a system. To address this goal and the secondary ones, the research methodology applied to this dissertation draws on the approach stated by Glass (1995). This methodology is commonly known as the "Engineering Method", and it is structured in four phases that should be cyclically performed: informational, propositional, analytical, and evaluative.

- The informational phase consists on collecting the current knowledge about the topic in which the Master Thesis is located to clearly state the problems and shortcomings of the domain. During this phase, the gamification concept, the existing platforms that apply it on learning contexts, and the advantages of this application were analyzed. Besides, a feature analysis was performed in order to highlight the weaknesses of the current gamification platforms used in learning contexts.

- In the propositional phase, potential solutions to amend the weaknesses identified in the previous stage are proposed (e.g. hypothesis, methods or models). This dissertation proposes the extension of the current architecture and data model of a system able to deploy learning situations. These proposals aim to the development of a system addressing the weaknesses of the existing gamification platforms previously identified.

- The purpose of the analytical phase is to explore the proposals and define how the contribution can solve the analyzed problem, leading to a demonstration and/or formulation of the proposed solution/s. A lifecycle of gamified learning situations is proposed and analyzed to obtain the requirements needed for the creation and management of the gamifications. This allows to determine the new components and elements that should be added to the architecture and data model used as the basis for the proposals presented in this dissertation.

- Finally, the last phase consists in evaluating the stated proposal by means of experimentation (controlled) or observation (uncontrolled). In this work, the evaluation has consisted on the development of a prototype able to gamify learning situations, in order to validate the feasibility of the proposal.

In the present work one iteration is implemented to validate the feasibility of the proposals. This iteration covers the scope of this dissertation. However, the fulfillment of the stated research goal would require new iterations, where improvements to the proposals were implemented, and where more comprehensive evaluations should be carried out.

1.5 Document Structure

The remaining structure of this document is as follows:

- In the next chapter, a literature review about gamification and previous systems able to gamify learning activities is exposed.
- Chapter 3 describes the proposed gamification system: its architecture and data model, and how could it solve the presented problem.
- To check the viability of the proposed gamification system, an evaluation was carried out. The description of the prototype, the evaluation and the results are exposed in Chapter. 4.
- Finally, Chapter 5 contains the conclusions obtained from this work and the future work.

Chapter 2

Literature Review

Resumen: Este capítulo describe los conceptos necesarios para motivar los objetivos y contribuciones de este trabajo. Además, se describen los diferentes análisis y decisiones tomadas durante las primeras etapas de su desarrollo, que corresponden con la fase informativa de la metodología adoptada. Tales conceptos comprenden la conceptualización del término "gamificación" y sus diferencias con otros términos utilizados en contextos similares (i.e. ludificación, diseños basados en juegos, juegos serios o juegos educacionales); las ventajas e inconvenientes de la gamificación; la diferenciación entre gamificación estructural y de contenido; la definición e identificación de los elementos de diseño de juegos utilizados para gamificar y la identificación y el análisis de las características de las plataformas de gamificación existentes. Se describe asímismo el sistema que utilizaremos como base para nuestra herramienta de gamificación de situaciones de aprendizaje: GLUEPS-AR. Este sistema es capaz de desplegar situaciones de aprendizaje que pueden incluir herramientas frecuentemente utilizadas en educación y en diferentes espacios, pero cuya capacidad de gamificación es actualmente limitada.

2.1 Introduction to Gamification

In the previous chapter, an overview of the dissertation research problem was proposed: the creation of a system that would help teachers gamify their own designed learning situations which may involve different kinds of resources and spaces frequently used in education. In order to understand and achieve the goals and contributions of this work, this chapter describes an introduction to gamification in education, the existing gamification frameworks and the existing gamification platforms. Moreover, it also exposes the analysis and decisions carried out to achieve the previous stated goals.

2.1.1 Conceptualization

Following the well-known definition of gamification exposed in Sec. 1.1, gamification in education can be considered as the inclusion of game design elements into educational contexts. Nevertheless, there has been controversy during the conceptualization process of gamification (De Sousa Borges et al., 2014). The usage of the gamification word has been used sometimes as a synonym of other similar concepts. Thus, in order to clarify these differences, we regard the necessity of starting this section by defining these similar concepts and conceptualizing the term “gamification”. Such similar concepts are: ludification, playful design, serious games and educational games (an overview of the relations between them is shown in Fig. 2.1).

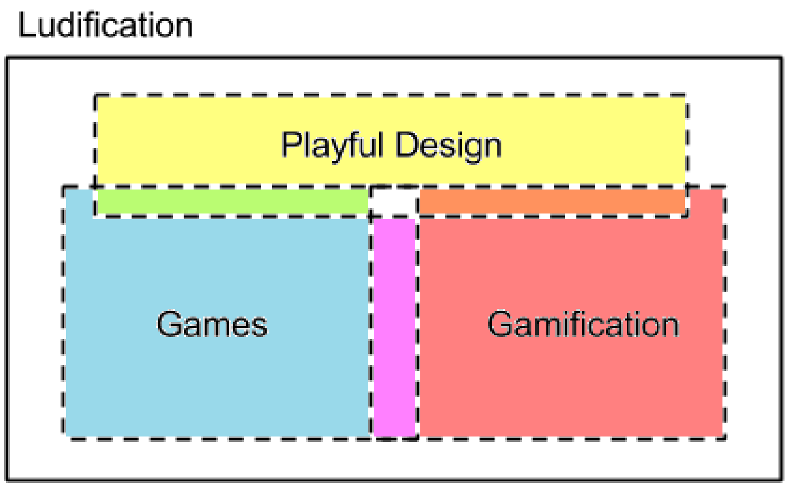

Figure 2.1: Conceptualization of gamification and similar terms.

Ludification

Ludification and gamification can be informally considered as synonyms (see the definion of Ludification and Gamification in the Wikipedia[1] where they are linked as synonyms). However, most gamification research authors identify them as different terms. Based on the meaning from the ancient greek, Bouca (2012) defines ludification as the process of becoming something funny and playable to the user. For instance, videogames, educational games, gamifications, or funny website designs are examples of ludification. Therefore, the dimension that makes “ludification” different from “gamification” is the playing/gaming spectrum, being the first broader than the second.

Playful Design

Playful design is defined as the design of funny utilitarian products (as most games try to achieve) (Fitz-Walter, 2015). It is a game-like approach to aesthetics and usability

[1] Ludificación: *https://es.wikipedia.org/wiki/Ludificación* and Gamification: *https://en.wikipedia.org/wiki/Gamification* [last access: July 2015].

that users perceive as funny when interacting with them (Marczewski, 2013). For example, one successful playful design example is Twitter's page known as "Fail Whale" that appears when Twitter is over capacity (De Sousa Borges et al., 2014).

Serious/Educational Game

A number of common variables are associated to the different definitions of game – rules, goals, voluntariness, outcomes, conflicts, fun – (Juul, 2010). The definition of game emerges from combining a variety of these variables in different proportions (Seaborn & Fels, 2015). Serious games are games whose purpose is different from entertainment and which are designed for non-recreational environments such as education, economics, health, industry, etc. (Simões et al., 2013; De Sousa Borges et al., 2014). When the purpose of the serious games is pedagogical, this kind of games are also called *educational games* (Klopfer & Squire, 2008). Although the frontiers between a gamified learning situation and an educational game can seem blurry, both concepts are different (Deterding et al., 2011).

On the one hand, the learning content of educational games is included into the game elements. The main goal that players should achieve in this kind of games is to perform the game goals (e.g. complete all the stages, be the first in the score ranking, etc.). The sequence of activities and players' actions lead to achieve these game goals and then, learning is produced as a side effect (Simões et al., 2013). On the other hand, gamification refers to the inclusion of game content into the learning activities. Although game content can create new goals to be reached by players such as getting all the badges or being the first in a ranking, the main goal of gamified activities is that the students perform properly the learning activities. In order to reach it, game design elements are included into learning activities. Thus, one of the main differences between gamified learning situations and educational games is the intentionality of the game design elements within the game or the activities.

Gamification

Once we have described the differences between gamification and the similar concepts, we can further analyze the definition of gamification: *the inclusion of game design elements into non-game contexts*. This analysis will help us identify issues that must be taken into account to accomplish the intended work.

- **Gamification uses game design elements**: gamification is not about creating games (e.g. videogames, serious or educational games) (Deterding et al., 2011). Game design elements are selected to move the effects that can create players' feelings (e.g. socialization, motivation, engagement, etc.) from games to other contexts. No author has defined the number of game game design elements that should be included in a context to consider it as a gamified activity or a gamification. Thus, for our purposes, we will consider in this dissertation that the inclusion of at least one game design element is enough to gamify an activity. Additionally, as discussed in

Sec. 2.3, we can consider different levels of gamification depending on the number and type of game desing elements included.

- **Gamification refers to non-game contexts**: although some authors have discussed about the gamification of games as Deterding et al. (2011) exposes, gamification refers to non-game contexts. Games could be gamified by including new game design elements along with the rest of game elements. For example, a game programmer could add achievements to a non-achievements game. However, it will be part of the game design and it will keep being a game instead of a gamification. Thus, although the process of adding game design elements can be performed within a game, we consider in this work the term "gamification" is tied to non-game contexts.

2.1.2 Benefits and Limitations

There is a popular positive belief in the effectiveness of gamification because most games are fun and intrinsically motivating (Hamari, 2015). Indeed, only the use of the word "game" can, in educational environments, increase the students' interest of the learning activities (Klopfer & Squire, 2008). However, if gamification is not properly applied either to the activities or the participants, it can drive to negative students' behaviors (Nicholson, 2012). Thus, this subsection summarizes the main benefits and limitations that gamification presents in the related literature.

The literature review about gamification in education carried out by Dicheva et al. (2015) shows that the majority of experimental studies of gamification report a significant higher engagement of the students in the learning activities. This is an important factor in education because when students are engaged in a learning environment, they are more likely to increase their willingness and desire to be successful within the activity (Dicheva et al., 2014). In fact, the objective of the first gamifications (carried out in the commercial sector), was to increase the customers' engagement: customer loyalty cards with points, personalized discounts, etc. However, engagement is not the only benefit of gamification. Literature also reveals that the inclusion of game design elements in learning environments can affect to other psychological and behavioral students' outcomes that could benefit them. For instance, the students' learning outcomes (Arnab et al., 2014), behavior (Hakulinen et al., 2013), socialization (De Sousa Borges et al., 2014), intrinsic motivation (Suh et al., 2015), extrinsic motivation and as exposed before, engagement (Muntean, 2011).

Nevertheless, some authors and experimental studies in gamification have argued and reported limitations when applying game design elements into learning situations. For example, Nicholson (2012) has argued that just using competition and a reward-based gamification system can lead to detrimental participants' outcomes since it only focuses on extrinsic motivation (Fitz-Walter, 2015). As a consequence, the use of game-like rewards such as points or badges can promote students to learn only when they are provided with external rewards (Lee & Hammer, 2011). This kind of gamified activities based on rewards can also lead students to be overly competitive. And this behavior can finally drive students to cheat and shelve the activity goals in order to get as many rewards as possible (Fitz-Walter, 2015).

The benefits of gamification in education have been experimentally tested, although these benefits can depend on the characteristics of the students. There are empirical results which show that gamified activities can increase not only students' motivation and engagement, but also other positive behavioral outcomes. However, the same gamified activities may not be meaningful to everybody (Nicholson, 2012; Dicheva et al., 2014). For instance, Koivisto and Hamari (2014) reported that the same gamified activities had greater social benefits for women rather than for men and that the use of gamification is shown to decline with age.

In summary, although gamification can sometimes involve negative outcomes (e.g. overly competitiveness, cheating), there is also evidence of its positive effects in education. Therefore, it seems reasonable to give teachers the capability of gamifying learning situations. Nonetheless, the lack of proper technological support is one of the major general obstacles to include the potential gamification benefits to education (Dicheva et al., 2015). Thus, the development of a system able to include these benefits by means of game design elements could provide significant advantages for the students.

2.1.3 Types of Gamification

There are many ways to gamify a learning situation. One of the most popular gamification classifications in the literature is Kapp's classification (Kapp, 2013). Kapp distinguishes between two types of gamification: *content gamification* and *structural gamification*. On the one hand, content gamification is the edition of the content of the activity (i.e. resources, goals, etc.) to make it more game-like. For example, the use of pixel-based graphics to describe the goal of the activities or the inclusion of a narrative story during the performance of the learning situation. On the other hand, structural gamification is the addition of game design elements "around" the learning situation content itself. In this approach, students must perform the same activities as if the gamification was not included. For example, the addition of a leaderboard that contains the time employed to complete an activity.

Content gamification implies that teachers should adapt their already designed activities to game-based patterns, story and style. This gamification process could result in an activity more game-like and attractive for the students. However, structural gamification creation process can be less complex for teachers since they do not have to change the content of the activities. In addition, most of the already created gamified learning situations and gamification platforms focus on structural gamification. Thus, this dissertation will also focus on structural gamification.

Hunicke2004 (MDA)	Zichermann2011 (Hunicke-based)	Bunchball2010	Simoes2013 (Bunchball-based)
Game Mechanics: “The various actions, behaviors and control mechanisms afforded to the player within a game context” **Example (shooter games):** Weapons, Ammo, Points.	**Game Mechanics:** “The elements that make up the functioning components of the game” **Example:** Points, Levels, etc.	**Game Mechanics:** “The various actions, behaviors and control mechanisms that are used to gamify an activity” **Example:** Points, Levels, etc.	**Game Mechanics:** “The rules and rewards of the game, intended to evoke determined emotions on the player” **Example:** Points, Levels, etc.
Game Dynamics: “Run-time behavior of the mechanics acting on player inputs and each others’outputs over time” **Example (shooter games):** Camping, Sniping.	**Game Dynamics:** The player’s interactions with mechanics. No explicit examples.		
Game Aesthetics: “The emotional responses evoked in the player, when she interacts with the game system” **Example:** Challenge, Fellowship, etc.	**Game Aesthetics:** “The composite outcome of the mechanics and dynamics as they interact with and create emotions” **No explicit examples.**	**Game Dynamics:** “The desires and motivations resulting from the interaction with mechanics” **Example:** Reward, Status, etc.	**Game Dynamics:** “The desires and motivations leading to emotions evoked by mechanics” **Example:** Reward, Status

Table 2.1: Most relevant frameworks of game design elements used for gamification (Part 1/2).

Deterding 2011	Dicheva2014 (Deterding-based)	Ortega-Arranz2015
Game Interface design patterns: “Successful interaction design components and design solutions for a known problem in a context” **Example:** Badges, Leaderboard, etc.	**Game Mechanics:** “Combination of the first two levels of Deterding’s classification” **Example:** Points, badges, etc.	**Game Mechanics (1st lev):** “The elements and rules that frequently appear in videogames; that can be used to gamify and which can evoke emotional responses in players” **Example:** Points, Badges, etc.
Game design patterns and mechanics: “Parts of the design of a game that concern gameplay” **Example:** Time constraint, Limited resources, Turns.		**Game Mechanics (2nd lev):** “Game elements that cannot be themselves included into the activities that want to be gamified, but can be used for the design” **Example:** Feedback, Time Pressure, Game goals, etc.
Game design principles and heuristics: “Evaluative guidelines to approach a design problem or analyze a given design solution” **Example:** Enduring play, Clear goals, etc.	**Educational Gamification Design Principles:** “Combination of the third and fourth levels of Deterding’s classification” **Example:** Accrual grading, progress, Instant feedback, etc.	
Game models: ‘Conceptual models of the components of games or game experience” **Example:** MDA; Challenge, fantasy, curiosity; Game design atoms; etc.		
Game design methods: “Game design-specific practices and processes” **Example:** Playtesting, Playcentric design, Value conscious game design	*“This category is not relevant for the gamified instructional design”.*	**Game Dynamics:** “Players’ behaviors and feelings created by the interaction with game mechanics” **Example:** Reward, Competition, Cooperation, etc.

Table 2.2: Most relevant frameworks of game design elements used for gamification (Part 2/2), and our proposal.

2.2 Gamification Frameworks

So far, we have defined gamification as the use of game design elements into non-game contexts. Game design elements are the elements and features that frequently appear in videogames and make them enjoyable and fun to play (Simões et al., 2013). But which elements belong to the set of "enjoyable and fun elements" and which not? Previous work has tried to identify and classify these game design elements. As there is not a clear agreed classification (Dicheva et al., 2014), this section exposes what we consider the most common game design elements frameworks in gamification (see Tables. 2.1 and 2.2). Afterwards, the framework which is used in this dissertation is presented.

2.2.1 Existing Gamification Frameworks

Gamification frameworks are used to classify and distinguish the different kinds of game design elements within a game. For our proposes, it is important to understand which are the possibilities (i.e. game design elements) that teachers have when gamifying learning situations. Thus, in this subsection the three most cited game design elements frameworks (according to Google Scholar) are briefly described. Based on them, some other authors have determined their own frameworks which are also described in Tables 2.1 and 2.2. These tables expose the different analyzed frameworks, their classifications, definitions and examples used by each author.

Levels of Game Design Elements (Deterding)

When Deterding et al. defined gamification, they underlined the existence of various levels of abstraction in game design elements (Deterding et al., 2011). They distinguished from concrete to abstract: (i) interface design patterns; (ii) game design patterns or game mechanics; (iii) design principles or heuristics; (iv) conceptual models of game design units; and (v) game design methods and design processes. The definition of each level can be found on Table 2.2. Based on this framework, (Dicheva et al., 2014) proposed a two-level framework. The first level, "game mechanics" combines the first two levels of Deterding's classification and comprises elements such as points, badges or progress bars. The second level, "educational design principles" combines levels (iii) and (iv) of Deterding's classification and includes elements such as accrual grading, feedback or students' freedom-to-choice (Dicheva et al., 2014).

MDA Framework

The Mechanics - Dynamics - Aesthetics (MDA) Framework is a postmortem analysis of game elements that allows to apply them outside of games (Zichermann & Cunningham, 2011). It was originally proposed out of the range of gamification by Hunicke, LeBlanc, and Zubek (2004), but first applied to gamification by Zichermann and Cunningham (2011). This framework classifies game design elements into game mechanics, dynamics, and aesthetics (see Table. 2.1). First, game mechanics are the elements and rules that take part of games. For example points, levels and badges whereas the latter defines how to interact with them (Ibanez, Di-Serio, & Delgado-Kloos, 2014). Second, game dynamics are the run-time behaviors created by the participants' interaction with the game mechanics. Finally, game aesthetics are the emotions that players can evoke by interacting with the game elements.

Game Mechanics and Dynamics (Bunchball)

Bunchball (2010) defined gamification as the application of game mechanics to non-game activities to change people's behavior. Therefore, comparing this definition with Deterdings' definition, game mechanics are considered as the unique game design elements to gamify. Agreeing with that, Bunchball took the definition of game mechanics from the MDA Framework: the various actions, behaviors and control mechanisms (e.g. rules and rewards) that are used to gamify an activity. Some given examples are points, levels, challenges and leaderboards. Bunchball agreed that the interaction of players with the game mechanics that compose gamification can lead to players' desires and motivations. Bunchball called these players' desires and motivations as game dynamics (e.g. reward, status, self-expression). This classification was also taken to the design of a educational gamification platforms (Simões et al., 2013).

Figure 2.2: Relation between game mechanics and game dynamics proposed by Bunchball. The green dots are the primary desire a particular game mechanic can fulfill, the blue dots show the other areas that it affects (Bunchball, 2010).

Moreover, Bunchball considered that there is a relationship between the game mechanics and the game dynamics they are able to evoke. Indeed, it proposed a mapping between game mechanics and dynamics which is shown in Fig. 2.2. This classification and mapping between game mechanics and dynamics have been taken into account by other cited authors such as (Muntean, 2011). However, this mapping has been neither checked with empirical evidences nor based in literature, so we consider that further work is need to confirm these relations.

2.2.2 Selected Gamification Framework

The previous game design frameworks are three of the most cited frameworks to classify game design elements with gamification purposes. These three frameworks do not agree neither in the number of levels nor in how they are called. Nevertheless, even though there is no global consensus, all of them have similar features. These features are analyzed below:

Game Mechanics

The aforementioned frameworks agree in the lowest level of game design elements classification: basic components that can be used in other contexts to gamify, such as points, badges, avatars, etc. These components are known as “game interface design patterns” by Deterdings’ Framework and “game mechanics” by MDA and Bunchball Frameworks. Taking the definition posed by Simões et al. (2013) (Bunchball-based) and Ibanez et al. (2014)(MDA-based), we can define what we call game mechanics as *the elements and rules that frequently appear in videogames that can be used to gamify and which can evoke behavioral and emotional responses in players*.

Some authors consider in this categorization elements and actions such as “feedback”, “visual progress”, “game goals”, “time pressure”, etc. Nonetheless, in our opinion, these elements cannot be themselves included as such into the activities that want to be gamified (although they can be used for the design). For example, “feedback” is not included as an element into the activities. Rewards, progress bars, etc. are the elements able to provide the feedback to the players. Or for example, players’ “time pressure” is generated by the inclusion of counters in the activity. This leads us to distinguish between these elements/actions and the previous defined game mechanics. Thus, in this dissertation we will differentiate between the first-level game mechanics (i.e. rewards, leaderboards, counters, etc) and the second-level game mechanics (i.e. feedback, visual progress, time pressure, etc.). Based on our game mechanics definitions, we have performed an analysis in the literature in order to identify the game mechanics most frequently used. Appendix. A shows the result of this analysis and the definition of the first-level game mechanics.

Following the classification made by Kapp about the types of gamification that distinguishes between content- and structural-based classification, we can realize there are some first-level mechanics related to structural gamification and some other to content gamification (Kapp, 2014) (see Fig. 2.3). On the one hand, there are some game mechanics that are related to users’ actions and do not modify the content of the activities such as rewards (e.g. points or badges) Thereby, the game mechanics that need users’ actions monitoring and are related to structural gamification will be referred from now on as GMs-SG (Game

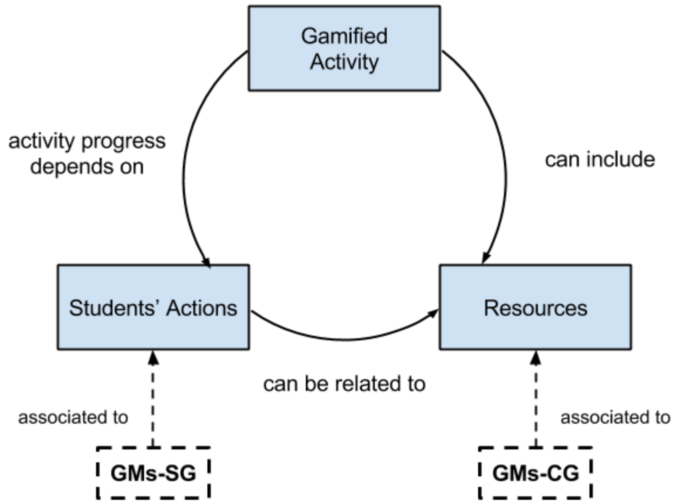

Figure 2.3: Application domain of GMs-SG and GMs-CG.

Mechanics-Structural Gamification). On the other hand, there is other kind of game mechanics which are more related to content gamification and try to make the activity more game-like. We will refer to them from now on as GMs-CG (Game Mechanics-Content Gamification). For example, story elements, avatars, game graphics, etc. A priori, unlike GMs-SG, this kind of game mechanics does not need actions' monitoring (see Sec. 2.1.3).

Game Dynamics

The MDA and Bunchball's frameworks agree that game mechanics are responsible of creating behaviors and feelings to players. For example, feeling rewarded, increasing competitiveness, cooperation, altruism, etc. The MDA framework names these behaviors and feelings as "Aesthetics" while Bunchball's framework calls them "Dynamics". This dissertation will follow Bunchball's nomenclature. As it happened with the game mechanics, there is not an agreed list that contains the behaviors and feelings that can be part of this classification. Thus, similar to game mechanics, an analysis of the identified game dynamics in literature has been carried out. Such result and the description of the dynamics are described in Appendix. A.

Mapping Game Mechanics - Game Dynamics

Gamification researchers predict that particular game mechanics could be able to evoke particular game dynamics, e.g. (Arnab et al., 2014). Therefore, not only gamification designs can be carried out with mechanics, but also with dynamics (reverse process). For instace, teachers can gamify an activity not only by including points and badges, but also trying to evoke a competitive response. Then, they should include into the activity, game mechanics that allegedly rise up that feeling in players such as some authors predicted leaderboards do (Sun, Jones, Traca, & Bos, 2015).

Currently, there is not much empirical research in the relation between mechanics - dynamics, and more work is required to obtain evidence about its effects (Domínguez et al., 2013; Dicheva et al., 2014). This dissertation goal is to help teachers gamify their own learning situations by providing them a system able to carry it out. One step further to help teachers when gamifying their learning situations could be giving them the opportunity to choose which emotional responses they want to evoke in their students. Then, the system could advise teachers which game mechanics should include into each activity. As aforementioned, this goal would require further research efforts in the relations between mechanics and dynamics.

2.3 Gamification Platforms: Review and Analysis

The inclusion of game design elements in learning activities seems a new opportunity for teachers to get students successfully perform learning situations. Due to this fact, many learning situations have already been gamified. In order to apply the gamification process in learning contexts, the game mechanics should be included in the actions and resources that compound the activities (Fitz-Walter et al., 2011). In digital contexts, this inclusion requires the programming of the activity resources, their interactions, the elements for the gamification, their visualization, etc. This programming requires a specific knowledge that common teachers do not have. Thus, the teachers that want to gamify their learning situations need the help and support of external programmers. These programmers gamify the contents and activities explicitly following the desires and directions of the teachers. We denote this kind of gamification as ad-hoc. One of the main advantages of this kind of gamification is the perfect adjustment to the learning situations and environments due to the craftsman work. However, this approach leads to a strong dependency between teachers and programmers during the whole lifecicle of the gamification, it is very demanding in resources, and therefore, it is not sustainable.

The so-called "gamification platforms" have been developed in order to avoid the dependency between teachers and programmers that ocurrs in ad-hoc gamifications. These platforms are tools designed to ease the creation of gamified learning situations in a more intuitive way. Each existing gamification platform provides different features to gamify the learning situations. In this section the main expected features in a gamification platform for education are studied. These features will allow us to analyze and compare the current gamification platforms used in education, by means of a feature analysis.

2.3.1 Features to Consider in Gamification Platforms

According to our approach to gamification, there are two important features that should be taken into account by gamification platforms: "the game content" and "the learning activities". Both features are described below.

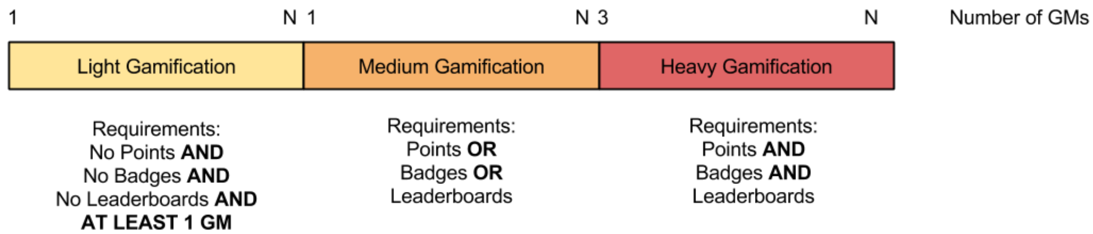

Figure 2.4: Proposed gamification spectrum for the gamification platforms analysis.

Game Content

Game content refers to the type and number of game mechanics that gamification platforms are able to include in the learning content. The number of mechanics these systems are able to include varies from one to many.

On the one hand, some systems have not been explicitly designed to gamify learning situations but are able to include some game mechanics in the activities design. For example, avatar customizations, time restrictions or levels of difficulty can be considered as game mechanics, but also other-domain mechanics. However, the inclusion of these game mechanics could not be flexible enough to gamify a learning situation according teachers' preferences.

On the other hand, other systems support the integration of a wide range of game mechanics in the gamification design process. Thus, based on the three most implemented game mechanics in gamified learning situations (according to the gamification-in-education systematic mapping study carried out by Dicheva et al. (2015)) gamification platforms can be classified. Following that mapping study, the most frequently used game mechanics are: points, badges and leaderboards.

Therefore, for our feature analysis, platforms will be classified as "heavy gamification" if they implement these 3 GMs-SG; "medium gamification' if they implement 'at least one of them; or "light gamification" if implement game mechanics but none of the most frequently used (see Fig. 2.4).

Learning Activities

There is a large amount of learning activity types that can be gamified. Thus, for our analysis we will consider the types of learning activities that gamification platforms may include in a learning situation.

Last technological advances, specially with the advent of powerful mobile devices, are enabling new possibilities for learning, such as those involving different virtual and physical spaces (Muñoz-Cristóbal, Jorrín-Abellán, et al., 2015). For instance, "The Geometry Mobile" project (Gil & Pettersson, 2010) aims that students learn geometry through the interaction between students' mobile devices and the real elements. This technological step has also been moved to the game-based learning and gamification field in both outdoors (e.g. Environmental Detectives (Klopfer & Squire, 2008)) and indoors (e.g. Musseum

Scrabble (Yiannoutsou, Papadimitriou, Komis, & Avouris, 2009)). Nowadays, learning can take place anywhere at every time, throughout formal and informal learning spaces (e.g. at home, in field trips, in virtual 3D worlds, etc.) (Muñoz-Cristóbal, Prieto, Asensio-Pérez, Jorrín-Abellán, & Dimitriadis, 2012). Thus, it seems desirable that gamification platforms are able to create learning situations in different learning spaces. Therefore, the capability of the gamfication platforms to create multi-space gamified learning situations will be considered as an important element for the gamification platforms feature analysis.

In addition, the last-years widespread trend is to centralize the learning contents, learning activities and assessment activities into just one single VLE (e.g. Moodle, LAMS, Blackboard) (Alario-Hoyos et al., 2013). Thus, we will consider an important factor in the gamification platforms whether they are able to deploy gamified learning situations within widespread VLEs such as Moodle, LAMS or Blackboarad.

Finally, it is desirable that the learning activities make use of tools already known by the teachers, such as Web 2.0 tools. These would be normally third-party tools, not developed by the same team as the gamification platform. Therefore, we will consider whether the gamification platform enables the inclusion of third-party tools in the design of the learning situation.

2.3.2 Feature Analysis

In order to know whether existing platforms or systems are able to create gamified learning situations with characteristics frequently used for learning, a feature analysis has been carried out. First, we have determined the features which are going to be analyzed. These features have been described in the previous subsection. Such desirable features in gamified learning situations are related to:

- (i) the game mechanics that the gamification platforms are able to include in the learning situations;
- (ii) the number of spaces that the gamified learning situations can involve;
- (iii) the type of environment where the gamified learning situations are deployed;
- (iv) the third-party tools and resources that can be included into the gamified learning situations;
- (v) the type of gamified learning situations they can create;

Next, we conducted a search of existing gamification platforms. We searched for gamification platforms using research repositories (i.e. Scopus, IEEE Explorer and Google Scholar) using the keywords "gamification", "platform", "education" and "learning" in different combinations. We also included in our analysis gamification platforms already known by the authors. The selected platforms are: Course Gam. Plat. (Dicheva et al., 2014), Schoooools.com (Simões et al., 2013), GLABS (Villagrasa, Fonseca Escudero, Romo, & Redondo Domínguez, 2014), ARIS (Gagnon, 2010), ARLearn (Ternier et al., 2012), QuestInSitu (Santos, Pérez-Sanagustín, Hernández-Leo, & Blat, 2011), GLUEPS-AR (Muñoz-Cristóbal et al., 2014), CaptainUp[2], Gioco.pro[3].

The result of the feature analysis is shown in Tables 2.3 and 2.4. Analyzing such tables we can conclude that:

- Those platforms that have been explicitly designed to support gamification can heavily gamify (i.e. including the game mechanics most used in gamification). Conversely, the capability to gamify of those systems and platforms that were initially designed with other purposes is light or medium (only by including points). The main shortcoming of platforms that support heavy gamification is that they are only able to deploy learning situations in virtual spaces. However, the remaining platforms support the deployment of activities in different physical and virtual spaces.

- Systems and platforms deploy their gamified activities in different virtual learning environments: learning management systems, mobile applications, web pages. Nevertheless, only GLUEPS-AR and Captain Up are able to deploy gamified activities in widespread VLEs such as Moodle (although GLUEPS-AR can perform it in a light gamification way).

- Those systems and platforms that allow the inclusion of resources/tools of third-party tools are able to provide teachers more opportunities in the creation of different learning situation types.

As exposed before, there are currently no systems that provide medium or heavy gamification to the learning situations with the desirable characteristics described above. Therefore, the implementation of a system with these learning features (i.e. multiple types of spaces, inclusion of third-party resources/tools and deployment in widespread VLEs) could provide teachers flexibility when creating learning situations. Moreover, if the same system is able to implement the desirable game features (i.e. heavy gamification mechanics), it would ease teachers when gamifying such learning situations.

The development from scratch of a platform/system to create gamified learning situation with the desired properties would imply too much effort. Thus, it seems reasonable start by modifying one of the analyzed platforms. Then, the remaining features and functionalities would be added. Different from the other platforms, GLUEPS-AR is a system able to deploy learning situations with all the aforementioned desirable features. However, its capability to gamify these learning situations is limited. Therefore, we propose to build our gamification system on GLUEPS-AR and add it the lacking gamification functionalities. Thus, in the next section the current GLUEPS-AR system is described.

[2] *https://captainup.com/*
[3] *http://gioco.pro/*

System/Platform	Game Mechanics	3rd-Party Tools	VLE Deployment	Types of Spaces	Types of Gamified Activities
Course Gam. Plat.	Heavy	No	The developed environment	Virtual	This platform allows the automatic rewarding of multiple choice, multiple answer, true/false, fill-in-the-gap, and matching questions.
Schooools.com	Heavy	Yes	Schooools.com	Virtual	Schooools.com is a social collavorative VLE where teachers can upload resources and (K-6) students perform the virtual activities. It proposes the manual and/or automatic rewarding when students interact with these resources.
GLABS	Heavy	?	Schoology	Virtual	GLABS is a gamification system which mainly focuses on content gamification. The exercises uploaded to Schoology are visualized in GLABS in a gamified way by students. It also allows the manual rewarding with points and badges.
ARIS	Medium	No	Mobile App.	Physical and Virtual	ARIS is a platform to create location-based, interactive, narrative-centric, educational experiences in a gamified way. Students can win attributes such as points when performing activities in each preset point of interest.
ARLearn	Medium	No	Mobile and Web App.	Physical, Virtual and 3DVW	ARLearn allows to create similar types of gamified activities than the ARIS platform. Then, students can be rewarded with points. Moreover, it allows to perform the activities within a 3DVW (i.e. Google Street View).

Table 2.3: Feature analysis of the selected systems and platforms able to gamify learning situations (Part 1/2).

System/Platform	Game Mechanics	3rd-Party Tools	VLE Deployment	Types of Spaces	Types of Gamified Activities
QuestInSitu	Light	No	Mobile App.	Physical and Virtual	Teachers can use QuesTInSitu to create location-based activities that involve multiple choice, multiple response and Yes/No questions. In this case, students' answers are sent to be assessed by the teachers without using any kind of reward.
GLUEPS-AR	Light	Yes	Moodel, MediaWiki, Mobile AR browsers.	Physical, Virtual and 3DVW	GLUEPS-AR allows to create learning situations that may involve physical, virtual and 3DVW spaces. Moreover, it allows to deploy resources from third-party tools in widespread VLEs such as Moodle. Nevertheless, the capability to gamify these learning situations is limited.
Captain Up	Heavy	Yes	Own Websites and Moodle	Virtual	This comercial solution allows to reward the interactions between users and webs by including programing code into the web files. Captain Up can be also installed on Moodle to reward the interactions with this VLE.
Gioco.pro	Heavy	Yes	Own Websites	Virtual	Similar to Captain Up platform. However, Gioco.pro does not implement leaderboards and cannot be integrated in Moodle.

Table 2.4: Feature analysis of the selected systems and platforms able to gamify learning situations (Part 2/2).

2.4 GLUEPS-AR

As we have previously analyzed, GLUEPS-AR is a system able to deploy a wide range of different learning situations. The lack of gamification functionalities in this system limits the implementation of the potential gamification students' benefits. Thus, it is proposed the modification of this system to heavily gamify the learning situations it deploys. To carry this out, this section analyzes the current capabilities of GLUEPS-AR and its architecture and data model.

2.4.1 Gamification Capabilities of GLUEPS-AR

GLUEPS-AR[4] is a system for the semi-automatic deployment of learning situations in different pervasive learning environments including VLEs (e.g. Moodle), Web 2.0 tools (e.g. Google Drive), AR mobile clients (e.g. Junaio) and 3DVGs (e.g. Google Earth) (Muñoz-Cristóbal, Prieto, et al., 2015). This system also allows to complete the learning designs with tools and resources that authoring tools are lacking. For instance, WebCollage[5] is an authoring tool which does not support the implementation of AR elements in learning designs. However, GLUEPS-AR can import such designs created with the authoring tool and include the AR elements that complete the learning situation.

Similarly to AR, most current learning-design authoring tools do not permit the inclusion of game design elements (i.e. game mechanics) into the learning situations they are able to design. Nevertheless, in this case, the capability of GLUEPS-AR to complete the learning designs with game mechanics is limited. Taking into account what we considered as game mechanics, GLUEPS-AR system is only able to include avatars and narrative story in the environments that permit it (GMs-CG). Therefore, if we follow our definition of gamification, the system GLUEPS-AR is able to gamify learning situations, but with many restrictions and limitations, just two mechanics of content. The first game mechanic is story narrative elements, which can be included into the learning situations through textual resources. Additionally, it is able to give the possibility to the participants of customizing their avatars in those tools that allow it. For example, in Google Street View, the user can see her avatar and the ones of other participants when she is carrying out actions in the virtual world.

However, most of ad-hoc gamifications and gamification platforms include a wide range of game mechanics (and not limited to GMs-CG) such as points, badges and leaderboards. Therefore, it seems promising if we are able to enlarge the capabilities of this system (i.e. GLUEPS-AR) when gamifying a learning situation. Then, teachers could use GLUEPS-AR to gamify their own learning situations regardless the learning environments they commonly use and the gamification type teachers would like to implement.

[4]GLUEPS-AR responses to the acronym of Group Learning Unified Environment with Pedagogical Scripting and Augmented Reality support (Muñoz-Cristóbal et al., 2013). Freely available at *http://pandora.tel.uva.es/svn/GLUE/trunk/GLUECore/*, [last access: July 2015].

[5]More info at *http://www.ld-grid.org/resources/tools/webcollage*, [last access: July 2015].

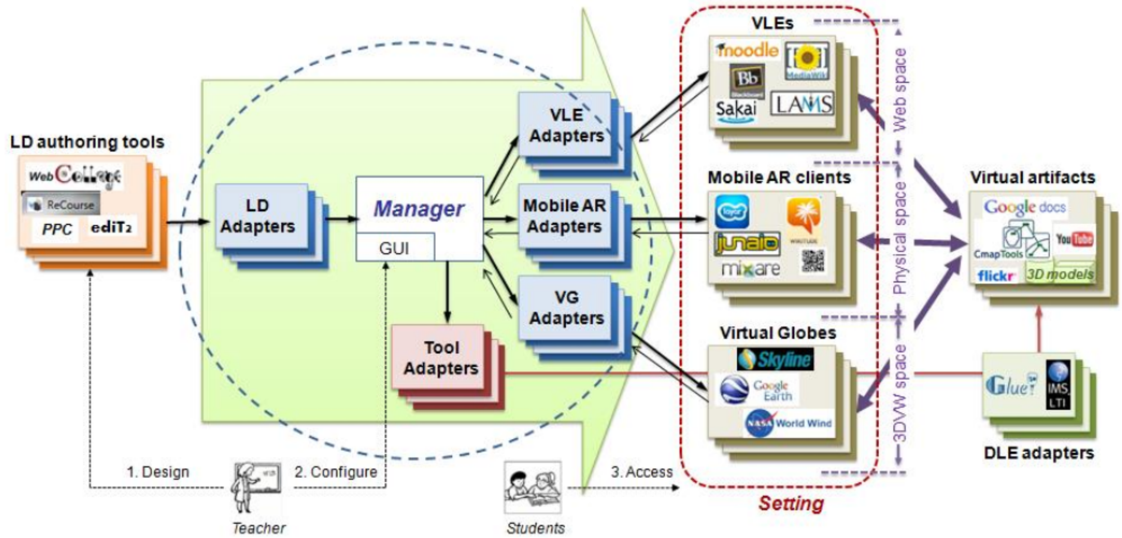

Figure 2.5: GLUEPS-AR architecture.

2.4.2 GLUEPS-AR Architecture

Fig. 2.5 (Muñoz-Cristóbal, Prieto, et al., 2015) shows the GLUEPS-AR top-level architecture. From a top-level view, GLUEPS-AR is composed of a central element called GLUEPS-AR Manager and a set of adapters. These adapters permit a loose coupling between the external elements (i.e. authoring tools and the enactment technologies) and the central manager. Teachers can use the Graphical User Interface (GUI) of the GLUEPS-AR Manager to import, complete and particularize (i.e. deploy) learning designs which have been already created with an authoring tool. For example, assigning specific students to groups, or tools to be used in each activity (Muñoz-Cristóbal et al., 2013).

To carry this out, first, the learning designs (LD) created with the authoring tools are integrated through LD-adapters that handle the data translation from each authoring tool format to the data model used by GLUEPS-AR (Muñoz-Cristóbal et al., 2013). Second, teachers configure and particularize the learning designs. Third, the configured learning designs are translated by means of the learning environment adapters in order to deploy the learning situations within the technological resources implemented in the learning design. Finally, these tools and resources can be accessed by students and teachers from any of the VLEs, mobile AR clients and VGs integrated in the system (Muñoz-Cristóbal, Prieto, et al., 2015).

GLUEPS-AR does not only works at the design and deployment phases, but also at enactment time. GLUEPS-AR Manager acts as a central hub for synchronizing and monitoring user information such as participants location (citar Game oF Blazons o Tesis Juan). Such an important point for gamification since as we have seen, some game mechanics (GMs-SG) can be related to real-time user actions. For instance, different badges could be rewarded depending on the activities performed by participants.

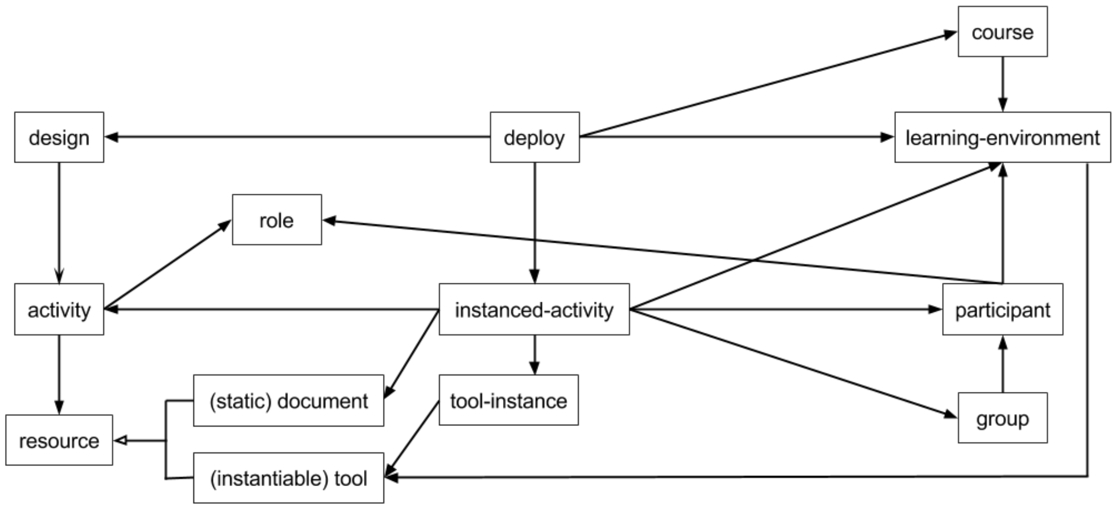

Figure 2.6: GLUEPS-AR data model.

2.4.3 GLUEPS-AR Data Model

GLUEPS-AR system utilizes its own data model because it performs two data conversions during the whole learning situation deployment process (Muñoz-Cristóbal et al., 2013): (i) from the output format of the authoring tool to the data model used by GLUEPS-AR; and, (ii) from the GLUEPS-AR data model to the one used by the DLEs, AR applications and the 3DVWs. Fig. 2.6 (Muñoz-Cristóbal et al., 2013) shows the current GLUEPS-AR data model (called Lingua Franca) briefly described below.

The GLUE!-PS Lingua Franca is based around the model of a learning situation design that can is composed by at least one learning activity. This learning situation *design* can be particularized, configured and *deployed* within a *course* in one or multiple *learning-environments* installation. Such a particularization of a design contains data about the concrete *participants* (e.g. the students who perform the activities), their *roles* and *grouping* (groups). As pervasive learning environments deployments are no restricted to VLEs, *instanced-activities* can be deployed in different learning-environments. These learning activities are mediated by *resources* (e.g. learning materials, tools), which can be static in design-time (*objects*), or instantiable during the deployment (*tools*). In the latter case (e.g., if it is needed that each group of students uses a different Google Docs document), a different *tool-instance* can be assigned to different groups or students (Muñoz-Cristóbal et al., 2013).

2.5 Chapter Conclusions

This chapter has described the concepts necessary to understand the objectives and contributions of this work. The most important concept is the conceptualization of gamification and its definition: “the use of game design elements into non-game contexts”.

Previous authors have exposed that gamification can affect to psychological and behavioral students' outcomes that could benefit them: learning outcomes, behavior, socialization and motivation. Such a promising feelings to get students engaged in learning environments. Nonetheless, the lack of proper technological support is one of the major general obstacles to include the potential gamification benefits to education (Dicheva et al., 2015). Thus, the development of a system able to include these benefits by means of game design elements could provide significantly advantages for students.

A feature analysis was carried out to determine the properties of the existing gamification systems. This analysis revealed there is not a system able to create medium or heavy gamified learning situations that may involve different spaces, may include resources from third-party tools and can be deployed in widespread VLEs. Following the analysis, we proposed to build a gamification system based on the GLUEPS-AR system.

Chapter 3

A Gamification System for Learning Environments

Resumen: Como se ha descrito en el capítulo anterior, la gamificación en entornos educativos puede afectar al comportamiento y a los sentimientos de los alumnos de una forma potencialmente beneficiosa en el aprendizaje. Con el objetivo de ayudar a los profesores a gamificar sus propias situaciones de aprendizaje, se han propuesto y desarrollado diferentes plataformas de gamificación. Sin embargo, estas plataformas presentan limitaciones en las situaciones de aprendizaje que son capaces de desplegar, en los elementos de gamificación que son capaces de añadir, o en ambos. Por eso, este capítulo describe la solución propuesta para conseguir un sistema capaz de desplegar situaciones de aprendizaje gamificadas que puedan incluir las características propias de las situaciones de aprendizaje actuales (i.e. desplegarse en VLEs, integerar herramientas de terceros y utilizar diferentes espacios). Para ello, previamente se modela un posible ciclo de vida de situaciones de aprendizaje gamificadas del que se obtienen algunos de los requisitos para la creación de tal sistema. Posteriormente, se propone la integración de estos nuevos componentes y sus interacciones sobre la actual arquitectura del sistema elegido para añadir la funcionalidad de gamificar (i.e. GLUEPS-AR). Finalmente, se propone una extensión del modelo de datos utilizado por GLUEPS-AR para soportar la gamificación de situaciones de aprendizaje. Tal modelo puede considerarse como un modelo genérico de situaciones de aprendizaje gamificadas.

3.1 Introduction

The previous chapter has presented the concept of gamification that will be used in this work, and the potential benefits that it can pose for the students in learning contexts. For example, increasing students' motivation and engagement or driving students' behavior within a learning situation. In order to help teachers include these benefits into the learning environments, some authors and enterprises have proposed and developed digital platforms to gamify learning situations. Nowadays, due to the rapid evolution of technologies, these learning situations may involve different spaces (i.e. physical and virtual spaces) and virtual resources physically positioned (i.e. Augmented Reality); may include third-party providers tools (e.g. Google Docs); and can be deployed in different VLEs (e.g. Moodle) (Muñoz-Cristóbal et al., 2013). However, as exposed in Ch. 2, the existing proposals and developments are not able to implement all of these features which are currently being used in learning contexts. This can be one of the reasons that explain the low utilization of gamification platforms. Thus, the main goal of this dissertation is to help teachers gamify learning situations that can involve resources and tools frequently used in learning contexts.

To achieve it, this chapter describes how to accomplish the secondary goals and contributions proposed for this work. Fulfilling the secondary goals described in the next section (i.e. to model the lifecycle of gamified learning situations and define how to automate it) will permit to identify the gamification requirements. Finally, these requirements have to be met to achieve the contributions of this dissertation: a system that allows the design and deployment of this kind of gamified learning situations; and a generic data model of gamification.

3.2 The Lifecycle of Gamified Learning Situations

As we have seen in the previous chapter, collaboration is a players' behavior (i.e. game dynamic) that gamification can provoke when applying game mechanics to a learning activity. Thus, although gamified learning activities do not compulsory imply collaboration, gamification could be included into the Computer Supported Collaboratice Learning (CSCL) research field. CSCL tries to find new forms of interactions among students to foster learning (Villasclaras-Fernández et al., 2009). In the CSCL community, multiple authors have modeled the phases that conform the lifecycle of CSCL learning situations (Rodríguez-Triana, 2014). Modeling the lifecycle of gamified learning situations will help us to understand which elements and actions should be included and performed in each phase to create them. Additionally, it will lead to identify which options should be offered to teachers and which elements should be deployed for a right performance of gamified situations. Although there is not a clear agreement neither in the number nor in the phases that CSCL scenarios should contain, some of them can be clearly identified. We will describe here these phases, following the ones proposed in (Rodríguez-Triana, 2014): Design, Instantiation, Management and Evaluation (see Fig. 3.1).

3.2.1 Design

This phase aims at the definition of the learning situations (e.g. resources and activity sequence) that lead to achieve the intended learning goals and important conditions which have to be accomplished (Rodríguez-Triana, 2014). For instance, teachers could choose the order of the activities, add or remove an activity, or associate a given tool to a specific activity (Dillenbourg & Tchounikine, 2007). In order to determine the students' outcomes (i.e. game dynamics) that want to be affected when including game design

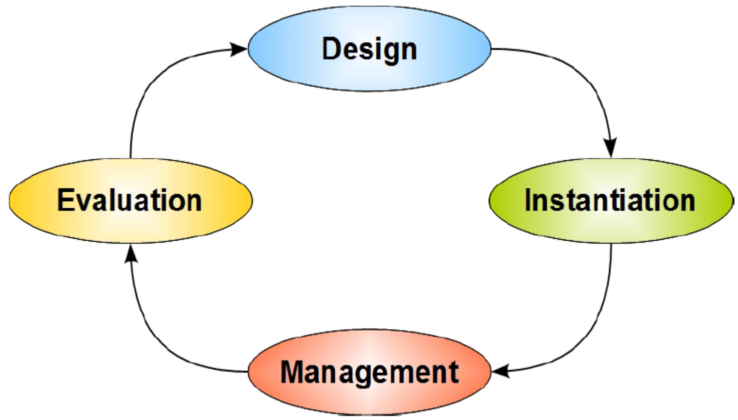

Figure 3.1: Phases of the CSCL learning situations lifecyle (Rodriguez-Triana, 2014).

elements, game mechanics have to be defined. Although there is not a clear mapping between game dynamics and mechanics yet, teachers can make some assumptions led by their overall educational experience. For example, if teachers want students to perform a concrete action in an activity, teachers can motivate students to do it by rewarding them with specific game mechanics (e.g. a badge or points). Thus, in a gamified learning activity, this phase can also include the definition of game mechanics that teachers want to apply to the designed learning activities.

3.2.2 Instantiation

The objective of this stage is to complete, set up and deploy the activities with the proper content. Teachers should specify the participants, roles, groups, resources, tools, spaces and any other feature that they want to be included in the learning situations (Rodríguez-Triana, 2014). Then, at the end of this phase, learning situations are deployed to be performed by students. Thus, if game elements were not included in the design phase, they have to be included, configured and deployed in the instantiation phase (as we consider in this dissertation). Teachers must decide which game mechanics to introduce, their design if necessary (e.g. badges need graphical and textual design), and their association with the remaining elements of the learning activities (e.g. when to reward points).

3.2.3 Management

This phase involves the monitoring of the deployed activities and their run-time management (Rodríguez-Triana, 2014). Sometimes, teachers need to make changes or actions while students perform the activities. For example, teachers can monitor the activities in case a question seems to be unclear for most students and no one has answered it (Dillenbourg & Tchounikine, 2007). As stated before, gamification can guide students during the activities performance, and increase their motivation and engagement through the use of rewards and comparative rankings (i.e. Structural Gamification Mechanics, GMs-SG). These GMs-SG depend on run-time students' actions within the activities (Fitz-Walter et al., 2011). Thus, this phase plays an important role in structural gamifications. Conversely, content gamification which aims to make the activities more game-like does not compulsory need monitoring. Thus, in this section we will focus on GMs-SG and students' actions.

The monitoring of students' actions in learning situations has been largely addressed by the Learning Analytics (LA) research community. Some of the proposals oriented to conceptualize the analysis process of educational data can be shown in Rodríguez-Triana (2014). Most of these proposals agree in three steps which compose the data analysis procedure: **(i) capture**, **(ii) processing** and **(iii) visualization**. Since gamification needs monitoring, these steps can be roughly adapted to conceptualize monitoring in the management phase of a gamified learning situation:

Capture

In the Capture step, the collection of data related to specified indicators is provided to a manager. These indicators represent the students' actions which have been previously chosen by teachers. For example, the collection of students' physical location (i.e. geographical coordinates) when accessing to a specific virtual resource of a learning situation.

Processing

The goal of the processing step is to extract meaning from the previous captured data. Teachers are responsible of choosing the requirements that monitored actions should meet. Thus, teachers should decide which conditions/rules the monitored actions must meet, and which game mechanics or rewards should be associated to them. For instance, the data about the students' physical location when they accessed to the previous virtual resource is processed to determine whether the students have accessed to this virtual resource from the expected physical place or not. Then, students' coordinates are compared with the reference coordinates and a proximity radius chosen by teachers.

Visualization

Finally, the processed information about the monitored actions performed by participants is presented. This step aims to show the results and processed data to interested targets such as students, teachers or researchers. In gamification, this information is frequently represented by means of game mechanics (e.g. leaderboards or badges) and shown to participants. Therefore, students can realize whether they are properly performing the activities or not.

The data analysis procedure carried out in the management stage can be addressed in three different ways. Depending on the number of phases performed by automatized digital devices we can classify the data analysis procedure in: manual, semi-automatized or fully automatized.

- Gamification monitoring is manually implemented when the whole process is performed without digital automatized phases. While students perform the activities, teachers can monitor with their eyes, process the students' actions and associate them with game elements in the physical world. For example, a teacher could be asking content-related questions to the students, and those who answer the right solution in a paper would be rewarded with points which are recorded in the board. The whole process (i.e. capture, processing if the answers are correct and the visualization of the rewards) is manually carried out by the teacher. This kind of monitoring process implies that teachers execute each step regardless the number of students that perform the gamified activity. Thus, many students performing the activity means that teachers will have to spend much time monitoring, and then, game mechanics feedback will be delayed. In the example above, fast feedback is not crucial, because it is a simple activity where all students advance in the activity at the same time. However, if we move to more complex designs and other gamification goals (e.g. affect students' behavior), there is a need of fast feedback to help students progress in their work.

- Semi-automatized gamification monitoring implies the automation of any of the previous steps. For example, different scores can be assigned to different physical locations that students have to reach in an activity. Automatized devices are able to capture the current students' locations. However these devices have not been configured to know which score has to be assigned to each location when students reach them. Thus, the captured data (i.e. students location) is presented to teachers to manually reward the students.

- The gamification data analysis procedure in the management stage is considered as fully automatized if every step of the monitoring process is digitally automatized: capture, processing and visualization. Teachers do not need to be involved in the whole gamification monitoring process. The deployed components in the instantiation phase allow to capture the configured data about users' actions and resources, process it, and let students visualize their game mechanics, providing close to real-time feedback to the students. For instance, in an activity in which students are rewarded with a badge when they successfully answer three questions in a row, the pre-configured automatized devices should be able to capture the students' answers, process them, reward them if conditions are met, and finally allow students to visualize the rewards.

Real-time rewarding is a typical feature of games that can allow students know their progress, be guided in real time and assess their performance. Real-time actions can encourage students to keep performing in the right way the activities in a learning situation. However, as we described before, manual rewarding process would strongly increase teachers' work load as well as the expended time for rewarding (i.e. leading to non real-time rewarding). On the contrary, the automation of the capturing, processing and rewarding gamification steps could achieve a closer real-time students' reward feedback. This justifies the need of deploying this kind of mechanisms when creating gamified learning situations. Nevertheless, there are some students' actions and resources whose monitoring process is not trivial. For example, text documents written by students whose assessment depends on teachers' judgement (Domínguez et al., 2013). Thereby, this dissertation should also consider this circumstance and give teachers the possibility of manually rewarding when it would be necessary.

3.2.4 Evaluation

The evaluation phase, also called diagnosis, is a post mortem activity revision which is eventually carried out to refine the previously performed activities (Rodríguez-Triana, 2014). Analyzing the previous captured or any other different monitored data during the enactment phase can be useful to evaluate the activities. Thus, if different data from the already configured for gamification wants to be used, it has to be also configured. For example, some gamification platforms such as Captain Up include useful analytics systems (e.g. number of actions per day) that can be used in this phase.

3.3 Extended GLUEPS-AR architecture for gamification

GLUEPS-AR is a system for the deployment of learning situations in different pervasive learning environments including VLEs, Web 2.0 tools, AR mobile clients and 3DVGs (Muñoz-Cristóbal, Prieto, et al., 2015). However, as seen in Sec. 2.4, the capability of GLUEPS-AR to deploy gamified learning situations with GMs-SG is limited.

The previous lifecycle model of gamified learning situations allowed to identify the functionalities that new components must perform within the architecture: capturing, processing and rewarding users' actions and storing and visualizing such rewards. GLUEPS-AR follows a multi-multi environments integration approach whose goal is to utilize existing third-party platforms and tools. Thus, in order to preserve such approach, the present proposal considers the integration of existing third-party gamification platforms to carry out the aforementioned gamification functionalities.

As analyzed in Sec. 2.3, there are no existing gamification platforms that perform the whole functionalities with the desirable features in education. Therefore, this dissertation will consider only those gamification platforms able to choose, store and visualize the game mechanics for each participant without the necessity of monitoring process. Then, the remaining gamification functionalities must be carried out by GLUEPS-AR system: capturing, processing and rewarding. These new elements are proposed to be included within the GLUEPS-AR architecture in order to support structural gamification. The new architectural components and their interactions are described in this section.

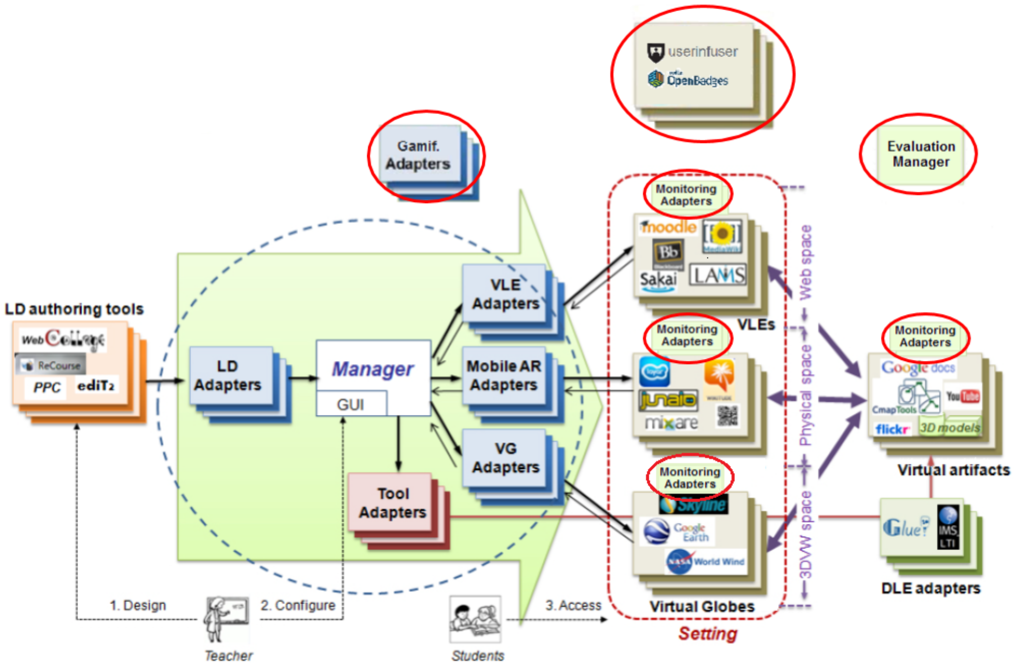

Figure 3.2: Proposed elements to extend gamification in GLUEPS-AR.

3.3.1 New Architectural Components

Following the stated lifecycle of gamified learning situations and the gamification platforms proposal, the new architectural components are described in this subsection (see Fig. 3.2):

- **Monitoring Adapters**: These adapters should be able to capture the data related to the students' actions that may involve GMs-SG. As the system can deploy learning activities involving VLEs, mobile AR clients, virtual globes and virtual artifacts, one Monitoring Adapter should be used for each environment. However, third-party tools can sometimes limit the monitoring capabilities. These third-party systems must be able to send the information (by means of GLUEPS-AR API) to the Monitoring Adapters, or receive requests that can be answered with the information required. Thus, depending on the technology used by each tool, the Monitoring Adapters will follow one of the two previous approaches. The Monitoring Adapters should also send the captured data to the component that will process it: the Processing Manager.

  The setup of the Monitoring must be performed in the instantiation stage to get an automatized monitoring process during the enactment of the learning situations. For instance, if a teacher wants to gamify an activity in a learning situation where students must collaborate by answering other students' questions on Moodle, and he wants to regard 100 points to the students that answer a post three or more times. Thus, in the activity enactment, the Moodle Monitoring adapter should capture that student identified as Juan has just answered a post in Moodle, and then, this information should be sent to the Processing Manager.

- **Processing Manager**: The aim of this new component is to carry out the second step of the gamification monitoring process. It must receive all the data captured by the monitoring adapters and analyze whether that data has any relation with the game mechanics used or not, and if actions meet the conditions. As exposed before, rewards can be given because students have performed an action at least *n* times. Therefore, data received by the Processing Manager must not only be processed at reception, but also stored with the other performed actions and be processed again.

  In order to automate this architectural component, types of actions, requirements that have to be met to reward, and the rewards must be set up in the instantiation phase. For example, the previous action performed by Juan is processed by the Processing Manager without reward. Then, the number of stored actions called "Answering a Moodle post" is incremented one unit and processed again. Once the requirements are met, rewards are sent to the Gamification Adapters to be stored and visualized in the Gamification Platforms.

- **Gamification Adapters**: Since GLUEPS-AR follows a multi-multi environment integration approach, different platforms can be used to store and visualize the game mechanics. As each gamification platform utilizes a different API, these adapters must translate the information from the GLUEPS-AR to each Gamification Platform data model. Not only in the management phase, but also in the instantiation one when students are being configured. For instance, following the previous example, when the userInfUser adapter receives the information about rewarding Juan with 100 points, the adapter translates it (by means of the UserInfUser API[1]) to *userinfuser.award_points("juan@alumnos.uva.es", 100, "for answering 3 posts");*.

- **Existing Gamification Platforms**: The Gamification platforms should let choose, store and visualize the game mechanics for each participant in a gamified learning situation. These gamification platforms must possess an API for setting up the preferences of the instanced gamification such as UserInfUser or Mozilla Open Badges. Previous to the management phase, students, selected rewards and their visualization should be configured. Then, in the enactment of the activities, gamification platforms should receive calls to their APIs to store and reward the game mechanics. .

3.3.2 Interactions at Instantiation Phase

In order to automate the gamification content of the management phase, teachers must previously configure and deploy the new proposed architectural elements. Such deployment and configuration involves the interaction between the GLUEPS-AR Manager (where

[1] *https://code.google.com/p/userinfuser/wiki/API_Documentation*

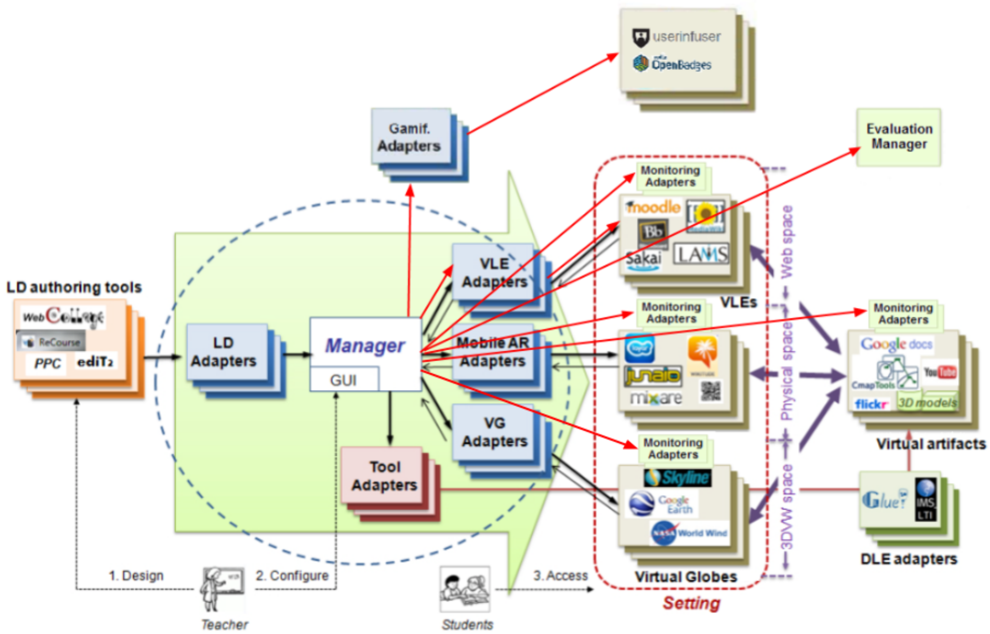

Figure 3.3: Gamification deployment interactions in the extended GLUEPS-AR architecture.

teachers select the gamification options through the GUI) and the other architectural components (see Fig. 3.3). These interactions are described below:

- **GLUEPS-AR Manager - Gam. Adapter - Gam. Platforms**: Before the enactment of the gamified learning situation, students must be set in the gamification platform. Thus, during the management phase, students can be rewarded in the platform and can visualize their rewards. To carry this out, GLUEPS-AR Manager should capture the properties of the learning situation participants during the deployment of such situation. Then, the GLUEPS-AR Manager must send the information about participants to the Gamification Adapter/s of the Gamification Platform/s[2] that will be used.

- **GLUEPS-AR Manager - Monitoring Adapters**: GLUEPS-AR Manager must inform monitoring adapters about the chosen students' actions that will be rewarded. During the deployment of the learning situation, GLUEPS-AR Manager must "enable" and set up the monitoring adapters that will be used (depending on the teachers' choices). This configuration corresponds to what has to be exactly monitored and the frequency of monitoring.

- **GLUEPS-AR Manager - Processing Manager**: GLUEPS-AR Manager must inform the Processing Manager about the rewards of each monitored action and the requirements to be rewarded. It must also inform about the gamification platform/s

[2]Mmore than one gamification platform could be used for the same learning situation.

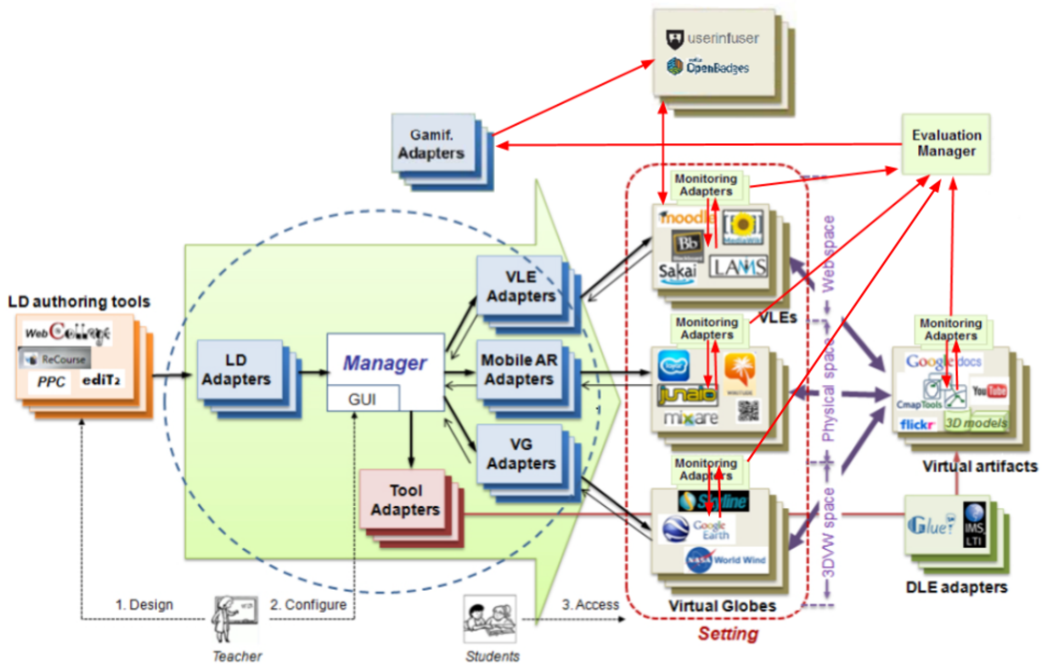

Figure 3.4: Gamification enactment interactions in the extended GLUEPS-AR architecture.

that will be used. Thus, depending on the used gamification platform, the Processing Manager will send the info with the rewards and the students to different Gamification Adapters.

- **GLUEPS-AR Manager - VLE Adapters - VLEs**: So far, we have described the basic interactions to create automated gamification during the management phase. However, when the VLEs are the core of learning situations, it might be interesting to embed the gamification platforms and/or the scoreboards in the same VLE. Thus, all the contents of the learning situation would be available on the same platform. Therefore, if it is possible and the teacher chooses it, GLUEPS-AR Manager should also be able to interact with the VLEs for such integration.

3.3.3 Interactions at Management Phase

Automation of capturing, processing and rewarding stages performed on gamified learning situations leads to new interactions among the architectural components in the management phase . Such interactions are represented in Fig. 3.4 and are described below:

- **Monitoring Adapters - VLEs/AR Clients/VG/Artifacts**: Monitoring Adapters periodically check the information related to actions that can be rewarded. For example, a teacher proposes students to write a summary (maximum 300 words) of a research article. A subtle way to let them know that they have reached the limit of 300 words could be giving them a medal when they have written 300 words. To do this, the Monitoring Adapter checks (with a preset frequency) the value of the number of written words through the Google API.

- **Monitoring Adapters - Processing Manager**: The information obtained from each query of the Monitoring Adapters is notified to the Processing Manager. In order to know if the action has to be rewarded, the information must contain at least the monitored action, the data captured and its value, and an identifier of the participant. For instance, an adapter which checks the number of written words in a document must sent to the Processing Manager the action that is being monitored, the number of words written and the students' identification.

- **Processing Manager - Gam. Adapters - Gam. Platforms**: Once the information captured has been processed, the Processing Manager recognizes whether the action taken by the student deserves a reward or not. If so, the Processing Manager shall notify the rewards to the Gamification Platform through the Gamification Adapters. The exchanged information should at least contain the type of reward and its value if necessary, and a student identifier. However, other parameters could be added, such as text notifications (depending on the properties of the used Gamification Platform).

- **VLEs - Gam. Platforms**: Finally, if the Gamification Platform or the scoreboards have been embed in a VLE, both platform and environment must interact to show the rewards in the VLE.

3.3.4 Extended GLUEPS-AR architecture: Final proposal

Taking advantage of the existing structure of GLUEPS-AR (see Fig. 2.5) and the current functionalities of its architectural components that have been analyzed in this section, the new proposed elements can be mapped to the existing ones. Currently, VG and mobile AR adapters already perform the monitoring of students actions such as participants' physical or virtual position. Extending this idea, the gamification adapters could be mapped to the existing VLE, VG, mobile AR, and Virtual Artifact adapters just adding them monitoring capabilities. In addition, the original GLUEPS-AR Manager is responsible of analyzing the captured information, process and show it to the teacher during the management phase. Therefore, the proposed Processing Manager could also be mapped to the original GLUEPS-AR Manager if the remaining gamification functionalities described before were added to it. Then, the only new architectural elements added to the current GLUEPS-AR architecture would be the gamification adapters and the gamification platforms (see Fig. 3.5). In order to simplify the figure, the interaction are only shown with the Gamification and VLE Adapters. However, the Mobile AR, VG and the Virtual Artifacts[3] Adapters could also interact.

[3]See that the name of this adapter has been changed from the previous GLUESPS-AR architecture to clarify the functionality of this component

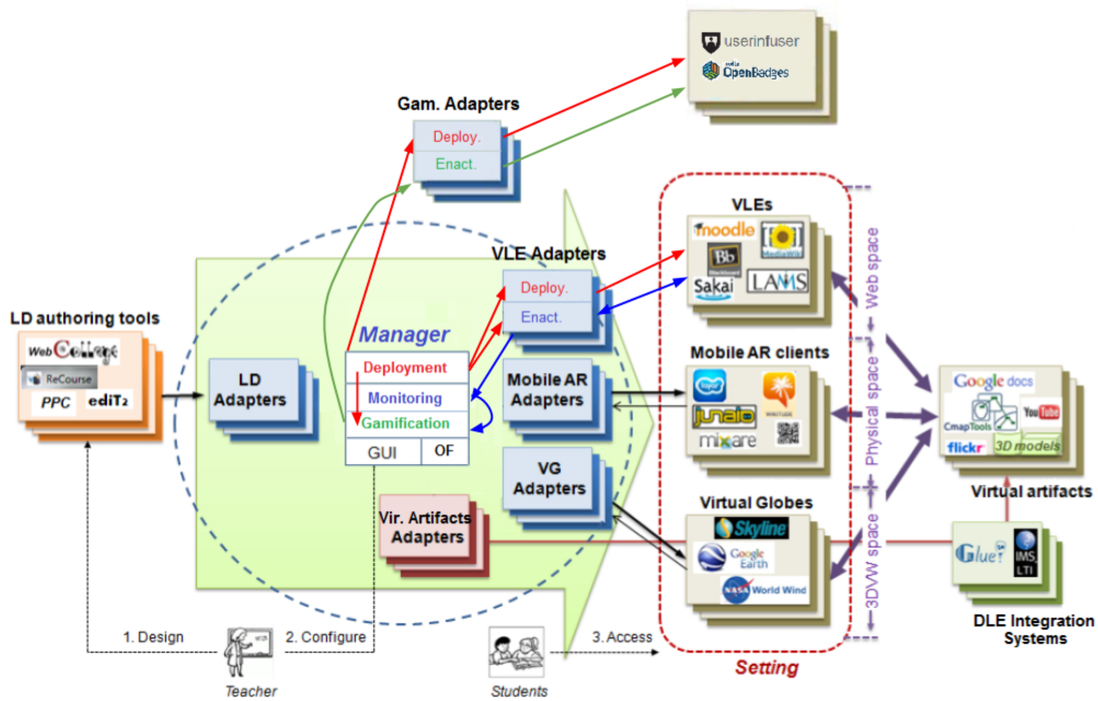

Figure 3.5: Proposed components and interactions to permit gamification in GLUEPS-AR. Red interactions are made at instantiation phase. Blue (Monitoring) and Green (Gamification) at management phase.

3.4 Extended Data Model for Gamification

Currently, GLUEPS-AR data model (i.e. Lingua Franca) (Muñoz-Cristóbal et al., 2013) can support the utilization of some game mechanics (i.e. GMs-SC). For example, the inclusion of a fictional narrative story that guides students' actions within the learning situations by means of textual resources during the different stages of learning situations. However, these GMs-SG cannot be mapped to any current data model element or attribute. Thus, in case that authoring tools could include this kind of game mechanics into the learning situations design, or when game mechanics are represented in the gamification platforms, new elements in the data model are needed. Therefore, it seems reasonable to extend the current GLUEPS-AR data model to provide gamification to learning situations. With the aim of analyzing which new elements and attributes should be included in the Lingua Franca to support structural gamification, two different approach have been carried out:

- *top-down approach*: Looking for standards related to gamification.
- *bottom-up approach*: Studying the components considered by existing public gamification-platforms APIs.

Elements	**UserInfUser**	**Playlyfe**	**ITPrism.com**	**Playbasis**	**CaptainUp**	**Google PS**	**BadgeKit**	**Gioco.pro**
User	user	player	user	player	user	player	earner	user
Group		team						
Action		action	activity	action	action	event		event
Condition		rule		rule	condition [reward property]			condition [reward property]*
Process		process						
Points	points	point [metric property]	points	points [reward property]	points [action property]	score		points*
Badge	badge	set [metric property]	badge	badge [reward property]	badge	achievement	badge	badge*
Leaderboard	leaderboard (widget)	leaderboard	leaderboard	leaderboard (widget)	leaderboard (widget)	leaderboard		ranking

Table 3.1: Summarized gamification platform API components analysis. * The complete API is not freely available, but videos show the existence of the element.

However, existing standards related to gamification have not been found. Thus, our analysis described below has been limited to the gamification components considered by other gamification-platforms APIs.

3.4.1 Gamification Platform APIs Analysis

This analysis aims to determine which are the common gamification concepts used by gamification platforms to implement the gamification functionalities. Such analysis has been carried out with the gamification platforms with public API found. The analyzed gamification platforms and their characteristic gamification elements are shown in Table 3.1[4]. Such characteristic gamification elements are[5]:

- **Users** are the players that perform the activities within a gamified learning situation.
- **Groups** are sets of users whose actions represents all the players of the set.
- **Actions** are basic triggers that allow to translate player events into measurable entities.
- **Rules** are certain conditions that users should meet to be rewarded.
- **Processes** make possible the creation of complex and flexible player journeys. The way processes are used depends on the type of gamified system you wish to make.
- **Rewards** are used to measure the performance of the players' actions in a gamification and assess their progress. There are different kind of rewards, the most used are:
  - **Points**: A numerical value which increases or decreases when players perform actions.
  - **Badges**: Unordered items that can represent player's actions and progress.
- **Leaderboards** are systems which rank players based on their rewards.

All of the reviewed platforms consider the user as the component who performs the actions and is rewarded. Some platforms also consider grouping users, so the actions a person in a group does are granted to every member of the group. All platforms allow rewarding users through points and or badges. Regarding the remaining elements, there

[4]UserInfUser: *http://code.google/p/userinfuser/wiki/API_Documentation* [last access: July 2015]
Playlyfe: *https://dev.playlyfe.com/manuals/* [last access: July 2015]
ITPrism.com: *http://cdn.itprism.com/api/gamification/index.html* [last access: July 2015]
Playbasis: *http://dev.playbasis.com/io-docs/* [last access: July 2015]
Captain Up: *https://captainup.com/docs/api/reference/overview* [last access: July 2015]
Google Play Services: *https://developers.google.com/games/services/web/api/* [last access: July 2015]
BadgeKit: *https://github.com/mozilla/openbadges-badgekit/wiki/* [last access: July 2015]
Gioco.pro: *http://github.com/GiocoApp/GiocoProAPI* [last access: July 2015]

[5]Based on the definitions provided by Playlyfe: *https://dev.playlyfe.com/* [last access: July 2015]

is a clear difference between the platforms that support the automation of all stages of monitoring and those which not. Those platforms which include rules/conditions and actions as elements of their data model (e.g. Playbasis, Captain Up), allow automation of monitoring and rewarding (although it is restricted to actions performed in the Web). Finally, most of the platforms allow creating leaderboards to compare the rewards between different users. However, many platforms consider it as a widget out of the data model used by platforms.

There is another analyzed component that is only conceived by the Playlyfe platform: Process. The processes can be considered as activity and resource variations in the flow of a gamified learning situation. For our purposes, processes could be implemented in a gamified learning situation through the proper configuration of the VLE, activities and resources. Its integration in the data model would add complexity. Therefore, this work does not consider it as an element of the data model.

3.4.2 Data model of the gamified learning situations

In Sec. 3.4.1, we have seen that most gamification platforms converge in the elements used to gamify. The current GLUEPS-AR data model will be taken as the basis of the proposed data model. Then, the gamification elements previously discussed are added to the data model. Some of these elements were already in part of the Lingua Franca (i.e. participants, groups). In addition to the previous elements, we will also include the "gamification platform" element. Like a learning environment where a course is deployed, participants of a course are also deployed in a gamification platform. Moreover, the rewards and visualizations chosen for a gamified learning situation depend on the selected gamification platform (chosen by the teacher).

The proposed data model is shown in Fig. 3.6. According to this model, *participants* are configured in a *deploy* in the selected *gamification platform*. Within an activity, participants can perform actions that may or may not be rewarding actions. Those *rewardable actions* performed by participants may or may not depend on *resources*. In order to finally reward a rewardable action, some *rules/conditions* may have to be met. If conditions are met, the action performed by the participant is associated to *rewards*. There are different types of rewards: points, badges, levels, etc. However, the utilization of different types of rewards depends on the *gamification platform* used for the implementation of the gamified learning situation.

Two aspects of the proposed model need further discussion:

- Rewardable actions can depend or not on the deployed resources. There may be rewardable actions involving resources or not. For instance, a possible rewardable action that could involve a resource is to answer a question in a document, while the distance walked in a physical activity is an example of an action which is not linked to a resource.

- Rules or conditions could be defined as a parameter within the rewardable actions since they depend on actions type. Nevertheless, there may be rules that make

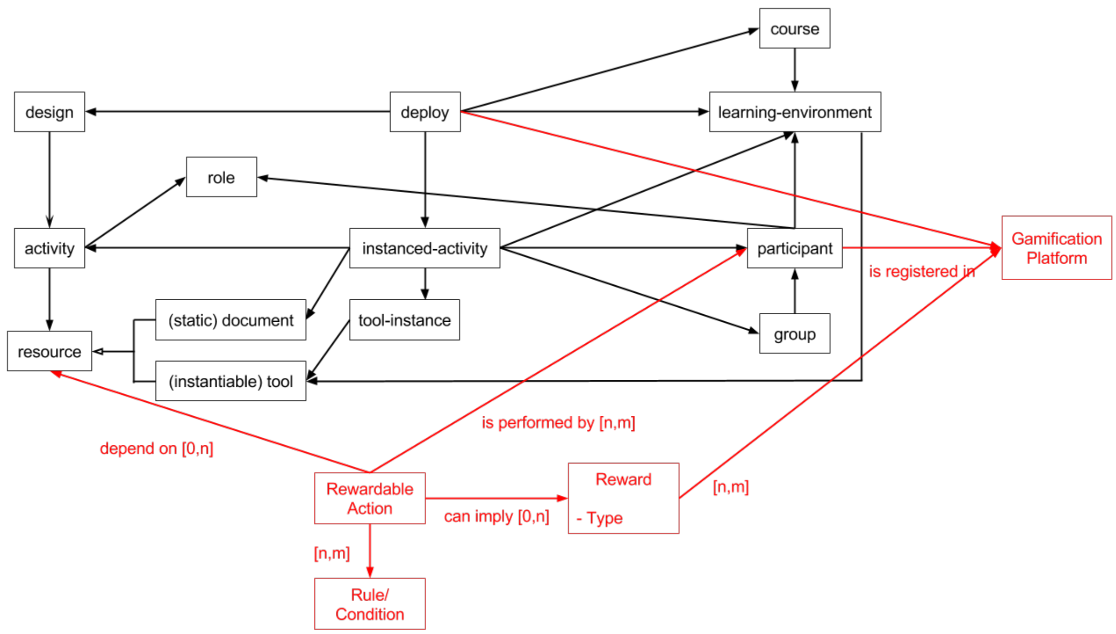

Figure 3.6: Extension of the current GLUEPS-AR data model to support the gamification of learning situations. The red section indicates the new extension.

sense with different types of rewardable actions. For example, if the action (e.g. post a comment or watch a video) is performed more than three times, the student is rewarded. It seems desirable that teachers are enabled to define their own rules and associate them to the rewardable actions in which the rule makes sense.

3.5 Chapter Conclusions

In this chapter we have presented a lifecycle of gamified learning situations. This lifecycle has allowed us to identify the requirements needed to create automated gamified learning situations. And finally, the lifecycle has led us to propose the architectural components needed to fulfill such requirements. These architectural components have been mapped or included into the architecture of the base system: GLUEPS-AR. With the addition of these new components, the learning situations that GLUEPS-AR are able to deploy can be gamified now.

The new architectural components are: (i) **Monitoring Adapters** have been mapped to the VLE, Mobile AR, VG and Virtual artifacts Adapters since Mobile AR and VG already capture information about students' actions. (ii) The **Processing Manager** is used to evaluate the actions, rules and rewards. This component has been mapped to the GLUEPS-AR Manager since this component currently processes the information received from the Mobile AR and VG Adapters in the management phase. (iii) **Gamification Adapters** must translate the gamification information from the GLUEPS-AR model to the chosen gamification platform/s model. (iv) The **Gamification Platforms** store, reward and allow to visualize the reward to teachers and students.

In addition, the current GLUEPS-AR data model has been extended to provide gamification to learning situations using third-party gamification platforms. To carry this out, an analysis of the concepts used by the existing gamification platforms has been performed. As result, we have proposed the addition of four new elements: (i) **Rewardable Action**: Actions performed by the participants that can be monitored and can be rewarded. (ii) **Rule**: Specific conditions that a rewardable actions must met in order to get the participants rewarded. (iii) **Reward**: recompense granted to participants due to the realization of a rewardable action. (iv) **Gamification Platform**: Platform where the participants of a gamified learning situation are deployed to store and visualize the granted rewards.

As we will see in the next section, both the architecture and the data model have been validated by means of a prototype implementing a subset of the possible types of gamification. It is possible that the proposed data model can not cover some cases of gamification (e.g. the processes we have decided not to consider for this work). Nonetheless, we have attempted to cover a wide range of cases without making the model too complex but still considering most of the elements considered by third-party gamification platforms.

Chapter 4

Evaluation

Resumen: La última fase de la metodología utilizada en este trabajo (Glass, 1995) consiste en la evaluación del trabajo desarrollado. Esta fase permite evaluar el objetivo y las contribuciones de este trabajo: *"Ayudar a los profesores a crear situaciones de aprendizaje gamificadas que pueden incluir recursos y herramientas comunes en educación y que pueden involucrar diferentes espacios físicos y virtuales"*. Sin embargo, evaluar si realmente se ayuda a los profesores excede el alcance de este trabajo, ya que requeriría la necesidad de un tiempo de preparación, de disponibilidad de profesores y de recursos tecnológicos que actualmente no se poseen. Por ello, la evaluación se ha enfocado hacia un primer aspecto: comprobar la viabilidad tanto de la arquitectura como del modelo de datos propuesto. Así, siguiendo con la metodología iterativa de Glass, en posteriores evaluaciones se podrían analizar otros aspectos que finalmente permitirían evaluar de forma global la consecución del objetivo de investigación definido en este trabajo. Para la evaluación presentada en este trabajo, que culmina la primera iteración del proceso de investigación, se ha construido un prototipo tomando como base GLUEPS-AR con algunas funcionalidades de gamificación, integrando elementos tanto de la arquitectura como del modelo de datos propuestos. Concretamente, estas funcionalidades de gamificación están relacionadas con la captación, procesado y recompensa automatizada de acciones realizadas por los participantes en un VG (i.e. Google Earth) y en el mundo real a través de un navegador de RA. Así, utilizando la interfaz gráfica del prototipo (basado en el la interfaz gráfica de GLUEPS-AR), los profesores pueden elegir las características de monitorización y recompensa de los alumnos que participan en las actividades dentro de la situación de aprendizaje. Por eso, este capítulo describe las características del prototipo desarrollado y un caso de uso en el que una profesora utiliza el prototipo para la creación de una situación de aprendizaje gamificada. Finalmente, se discuten los problemas detectados durante el desarrollo de esta fase y se obtienen unas conclusiones del trabajo desarrollado.

4.1 Introduction

The last phase of the proposed methodology to carry out this dissertation (Glass, 1995) is the evaluative phase. This phase allows evaluating the main goal and contributions of this work: *"To help teachers create gamified learning situations that can make use of resources and tools frequently used in education and that may involve different physical and virtual spaces"*. However, evaluating whether teachers are really helped by our proposals is beyond the scope of this work. It would require time for preparing the cases or the experiments, availability of teachers and technological resources that are not available at this stage. Therefore, the assessment has focused on a first aspect: checking the viability of both the architecture and the data model proposed. It can be noted that, following the Glass iterative methodology, other aspects could be analyzed, that would eventually lead to a global assessment of the achivement of the research goal identified in this work.

For our evaluation, we have built a prototype drawing on GLUEPS-AR. As described in the previous chapter, this system has been extended with some functionalities for gamifying the learning situations, by integrating elements from both the architecture and the data model proposed. These gamification functionalities are related to the capture, processing and reward of students' actions. Due to time restrictions, the students' actions implemented by the prototype are limited to geopositioned interactions with resources and special locations placed in AR browsers and VGs. Through the use of the graphical interface of the prototype, the teachers are able to chose the different features of monitoring and rewarding students that participate in the learning-situation activities. This chapter describes the characteristics of the developed prototype, a case study where a teacher uses this prototype to create a gamified learning situation, and the modifications required to integrate it with the GLUEPS-AR software. Finally, the problems detected during this phase and some conclusions from the work developed are also discussed.

4.2 Prototype Features

This section describes the features of the prototype that has been implemented to evaluate the two proposals presented in this work: an extended GLUEPS-AR architecture and data model (See Ch. 3). Due to time restrictions, the developed prototype implements a subset of the elements defined in these proposals, that have been considered sufficient to perform this first evaluation. This section describes the main features of the prototype.

4.2.1 Implemented Architecture

As aforementioned, the prototype implements partially the extended GLUEPS-AR architecture that is being evaluated in this chapter. We present below the new architectural elements implemented and their main features:

- Monitoring Adapters: They are responsible of capturing the students actions that can be rewarded. As explained before, there is a large amount of potential rewarding students' actions and we should choose a set of actions that could be rewarded.

Currently, GLUEPS-AR monitors (each five seconds) the students' location virtually in VGs and physically with AR mobile browsers. Moreover, the system recognizes when a student has interacted with an activity resource. These monitorings are performed by the VG adapters and the mobile AR adapters. Thus, these already integrated monitoring capabilities have been used to capture students' actions that can be rewarded. Therefore, the type of actions performed by the students that can be rewarded automatically by the system are: (i) to reach physically or in a VG previous configured locations[1]; and (ii) to interact with geo-positioned resources. The remaining proposed monitoring adapters (i.e. VLE Adapters and DLE Adapters for capturing students actions) have not been implemented, although they would follow a similar philosophy.

- Processing Manager: This element is responsible of processing the data captured by the monitoring adapters, and evaluate whether the students' actions should be rewarded or not. This architectural component must take into account the previous preferences configured by teachers when creating the gamified learning situation. For example, she must choose which students actions have to be monitored, the times that an action has to be performed to be rewarded, the number of points granted, etc. This element has been developed from scratch within the prototype. It is only used during the management phase if the teacher has selected the gamification option when creating the learning situation.

- Gamification Adapters: These adapters must translate the information from GLUEPS-AR to each Gamification platform data model. The developed prototype only includes a single gamification adapter (to connect with the Userinfuser gamification platform). However, one potential future work is to develop more gamification adapters to use other gamification platforms when gamifying learning situations (e.g. Mozilla Open Badges). Then, teachers could choose the gamification platform that fits better to their preferences. The developed adapter is responsible of translating the data model used by GLUEPS-AR to the data model used by the Userinfuser platform. This new element utilizes its open API to interact with the gamification platform.

- Gamification Platforms: There are different third-party gamification platforms. For our purposes, gamification platforms should let choose, store and visualize the game mechanics for each participant in a gamified learning situation. For this prototype (according to the gamification adapter used) we have chosen the platform Userinfuser[2]. Userinfuser is an open source platform that provides customizable gamification elements. Its API is easy to integrate in different language programs such as Java which is used by the GLUEPS-AR server. Moreover, this platform has a GUI to manually carry out any kind of management that the API does not allow (e.g. see rewards analytics). These reasons has led us to use this gamification platform for the prototype.

[1]Calculated with the Bessels law of cosines for sides of spherical trigonometry.

[2]*https://cloudcaptive-userinfuser.appspot.com/adminconsole*

4.2.2 Implemented Data Model

Like the architecture, the prototype development has included the new data model. The new implemented data model elements compared with the GLUEPS-AR data model are:

- Gamification Platform: In the gamification platform, the participants of the learning situation are deployed automatically. The gamification platform is responsible of storing the rewards and showing them to the students. Thus, one of the properties of this element is the type of visualization of such rewards: scoreboard, showcase, leaderboard, etc. Nevertheless, in the prototype, the visualization of the rewards is fixed and cannot be chosen by the teachers. It seems desirable the inclusion of these type of visualizations within the VLEs. With this, the students could watch their rewards in the same VLE where the activity resources are deployed. However, in the first stage of the prototype, the visualization is implemented in an external web page where participants can watch their score and a leaderboard with the score of the rest participants.

- Rewardable Action: The rewardable actions must be monitorable actions: by the prototype in case of automatic or semi-automatic mode or by a person in case of manual rewarding. As explained before, there is a large amount of potential rewardable actions in learning situations. In addition, the more technologies and resources are used in a learning situation, the more types of actions can be rewardable. In order to reduce the development time and leverage the existing GLUEPS-AR code, our prototype implements two types of rewardable actions (explained in the previous subsection): (i) to reach physically or in a VG to previous configured locations; and (ii) to interact with geo-positioned resources. As described in the proposed data model, these actions can be related to resources or not. In our case, we can distinguish how the former action is independent of the resources of the learning situation, while the latter action is not.

  Moreover, each rewardable action may be subject to conditions or rules to be rewarded. For example, the realization of the same action *n* times. The prototype allows teachers to choose one of these conditions, enabling limited to a single reward performing the same action. In the proposed data model, these conditions represent a different element since the same condition can be applied to different rewardable actions. However, in order to simplify the prototype development, we have included the "condition" element as a property of the two rewardable actions.

- Reward: They can be represented by different mechanics: points, badges, levels, etc. In our case, the prototype only allows to automatically reward with points, although the gamification platform can also allow the automatic rewarding with badges. Teachers can choose the quantity of points per rewardable action. This quantity can be positive or negative. Then, teachers can positively reward or on the contrary, punish the students actions with negative rewards. Such rewards are visualized by both teachers and students through the gamification platform. Thus, gamification platforms limit the type of rewards that can be used to gamify a learning situation.

4.3 Prototype Use Case

In this section a use case is presented: A teacher deploys a gamified learning situation using the developed prototype. The main goal of the learning situation is to motivate the students to understand the features and existent remnants of the Main Square of Valladolid physically. This learning situation contains a single activity involving different virtual resources that are geo-positioned in different locations, and existent elements of the square. The purpose of gamifying this activity is to increase the motivation of the students when performing some specific actions of the exercise. The gamification process of the activity is explained in the rest of the section.

Initially, the teacher should create a learning design with a proper learning design authoring tool (e.g. WebCollage) or using an already existent deployment of a previous design. In the design phase, the teacher includes the students, the groups and the number of activities required for the learning situation. In the deployment phase, the teacher configures the resources that will be used during the enactment phase.

In our case study, the teacher creates a learning design from scratch. Then, she uploads it to the prototype server, and configures the resources, which are two Google Documents (see Fig. 4.1). One document contains pictures of the main square of the past, together with some questions. The second one contains other questions related to the historical remnants of the square. Both documents have been geo-positioned in different locations of the main square, and they should be found by the students.

Once the resources have been configured, the teacher configures the gamification section in order to program automatic rewards during the enactment (see Fig. 4.2). In case that the teacher is not previously registered on the gamification platform (i.e. Userinfuser), she must do it through the link shown in the graphical interface. Once she has registered, she must include in the form the email address registered and the "API-key" sequence provided for this deployment. Then, the teacher should choose which actions will be rewarded in the learning situation. The implemented prototype offers two options: (i) to reach physically some particular coordinates using an AR browser or an VG avatar, or (ii) to interact with the resources located in specific coordinates.

Regarding the first type of actions (see Fig. 4.2), the teacher proposed to automatically give 25 points as a reward to the students that reached one of the corners of the main square. Such locations are close to real plaques which contain information needed to complete one of the documents of the learning situation. These specific locations have been previously configured in the deployment phase by the teacher, using geographic coordinates (i.e. latitude and longitude), and a radius in order to create an action area to interact (due to possible vagueness of GPS devices) (see Fig. 4.2). Besides, the teacher has added an additional reward of 25 points in the location of another plaque not positioned in a corner. These rewards are only given once per student. This behavior is also configured by the teacher. Regarding the second type of action, the teacher has decided

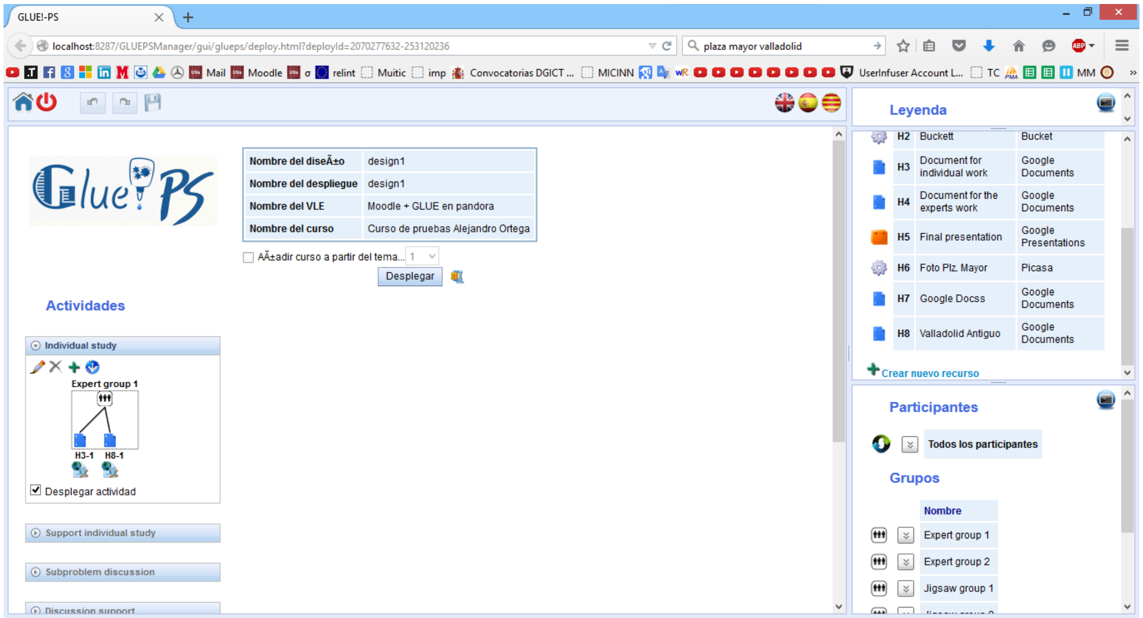

Figure 4.1: Screenshot of the configured resources utilized in the gamified learning situation of the use case.

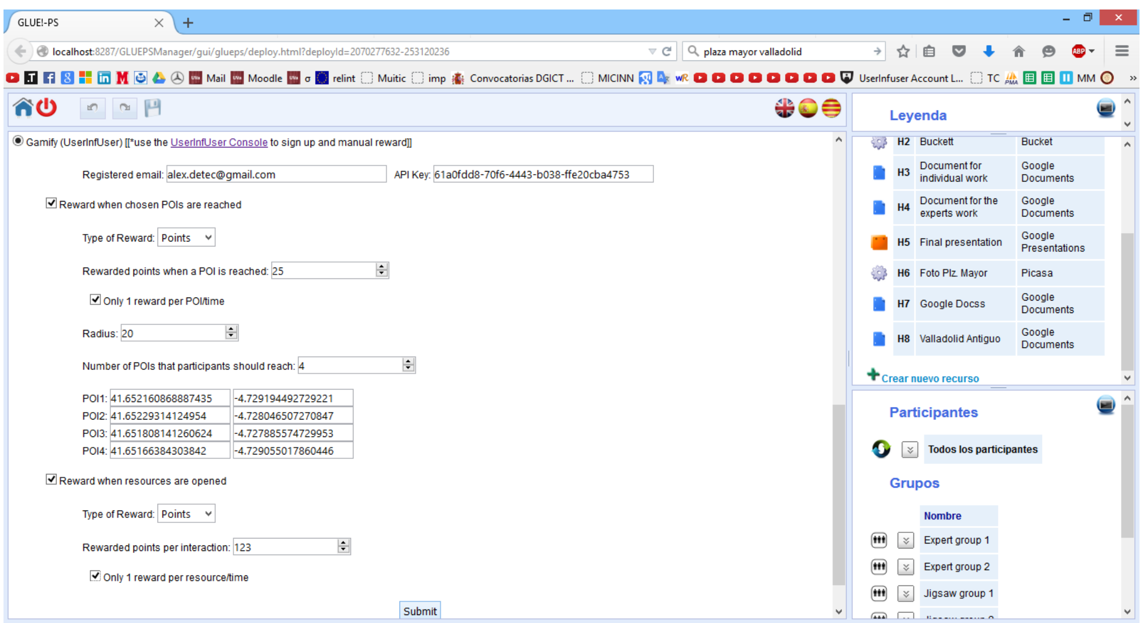

Figure 4.2: Screenshot with the configured gamification inputs in the learning situation of the use case.

to automatically reward with 123 points to those students that discover and access a new geo-positioned document in the main square.

Once the learning situation is deployed, the gamification platform automatically records the students who participate in this situation (see Fig. 4.3). With this, the instantiation

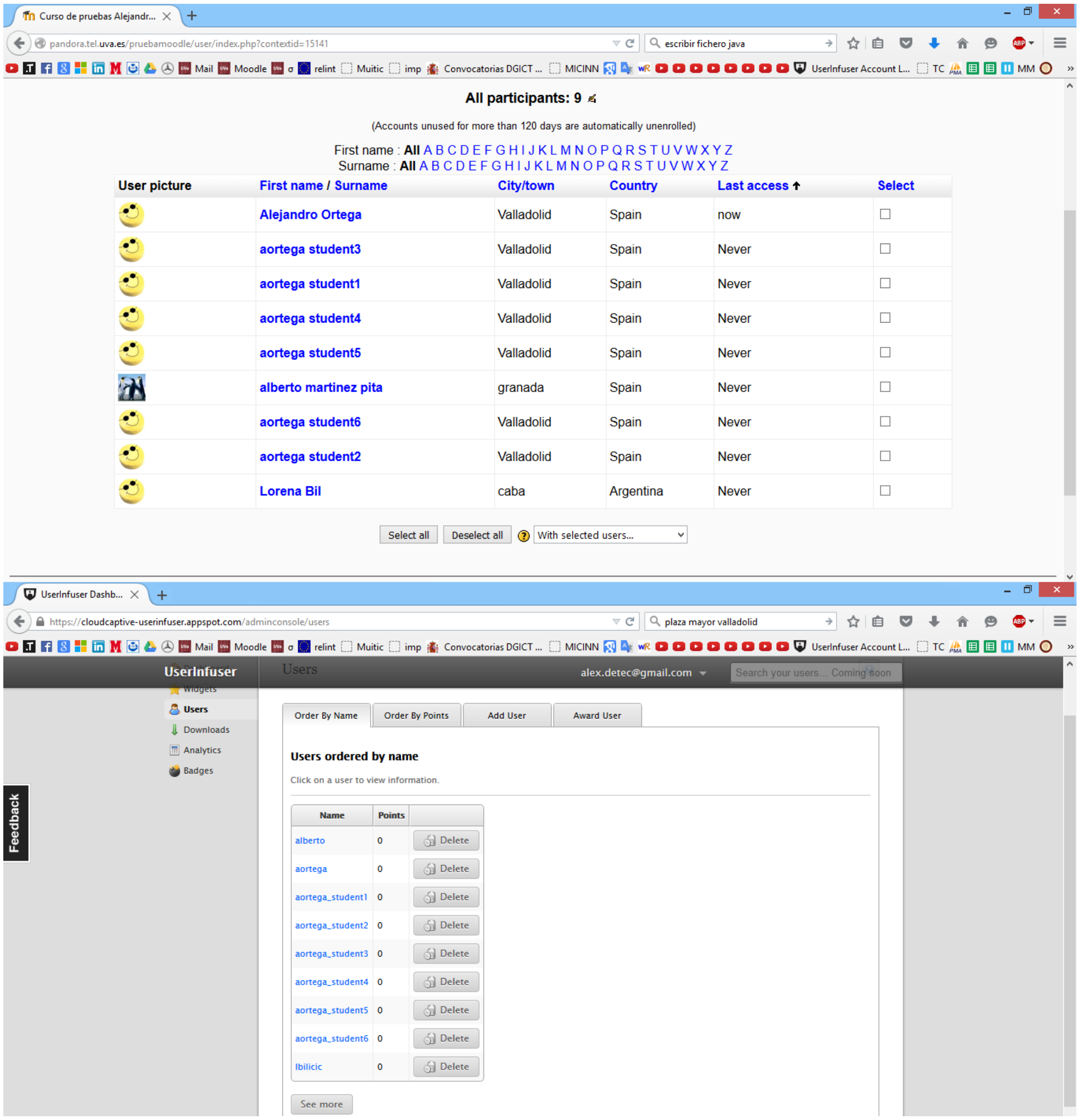

Figure 4.3: Above: The students deployed in the VLE (i.e. Moodle). Below: The same students deployed in the gamification platform (i.e. Userinfuser). Students are added in both cases when the "Deploy" button is pressed.

phase of the gamified learning situation can be concluded. Then, the teacher can use the gamification platform dashboard to monitor the progress of the situation (e.g. the awarded points in real time).

During the enactment phase, students must go to the mayor square with their mobile devices (with an AR browser such as Junaio installed) [3]. Then, when students interact with

[3]For the screenshots of this use case, we use a VG (i.e. Google Earth) instead a mobile device and an AR browser. The application behavior should be the same in both cases.

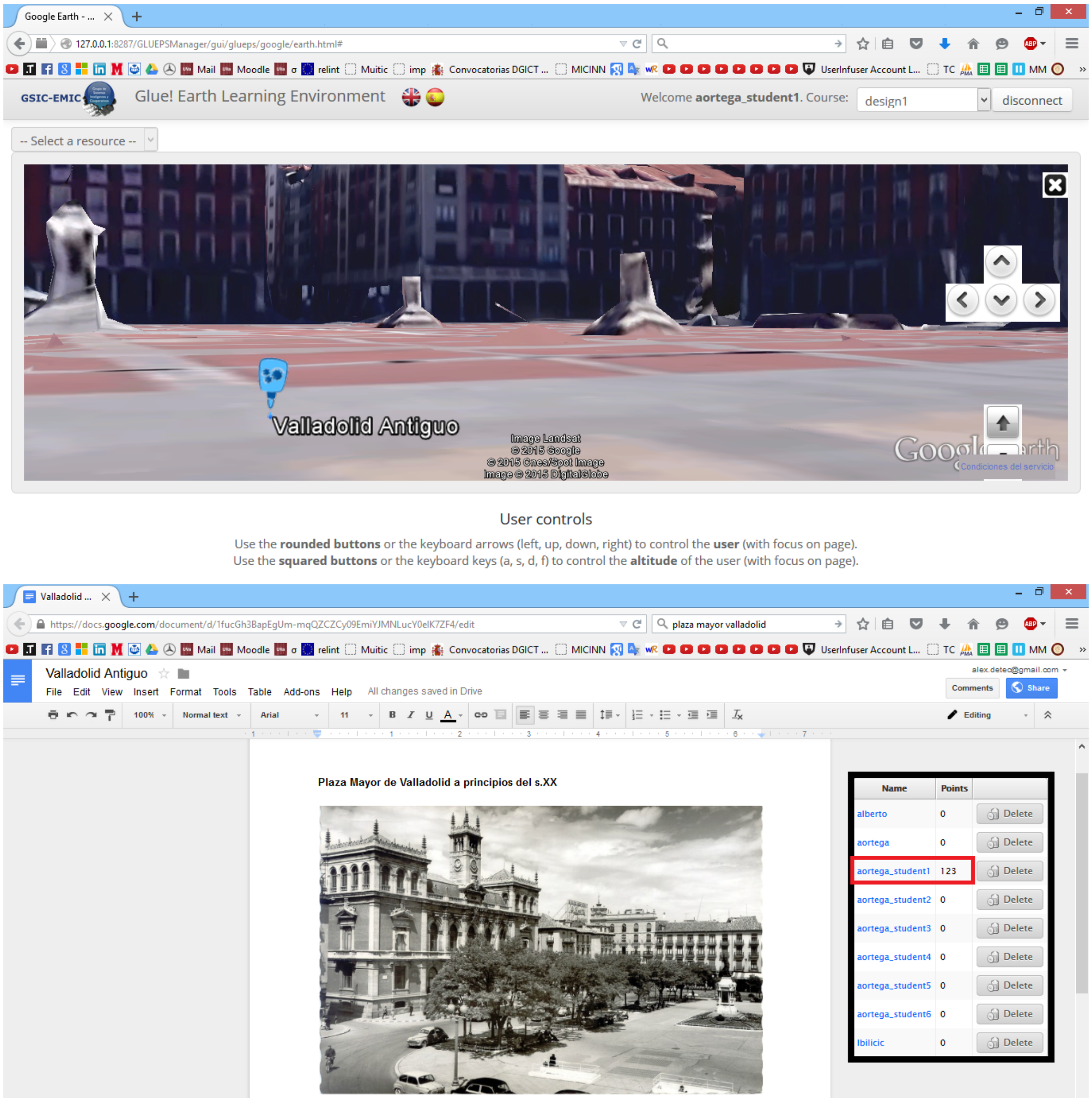

Figure 4.4: Above: The geo-located resource "Valladolid Antiguo" found by aortega_student1. Below: The content of the resource and the teacher's gamification dashboard on real time (aortega_student1 has been rewarded with 123 points).

the geo-located resources, they receive 123 points (see Fig. 4.4). Furthermore, when they get close to any of the points at the corners in a shorter radius set (in this case 20m), they are automatically rewarded with 25 points as previously preset by the teacher. As students reach more "points of interest" configured by the teacher, they add more points into their scoreboard (see teachers' dashboard on Fig. 4.5). Thus, students who have reached more points of interest and have interacted with more resources will gather more points. In order to prevent students of getting only points instead of looking at the plates, and then, fill the documents incorrectly, the teacher can manually reward the answers of students in

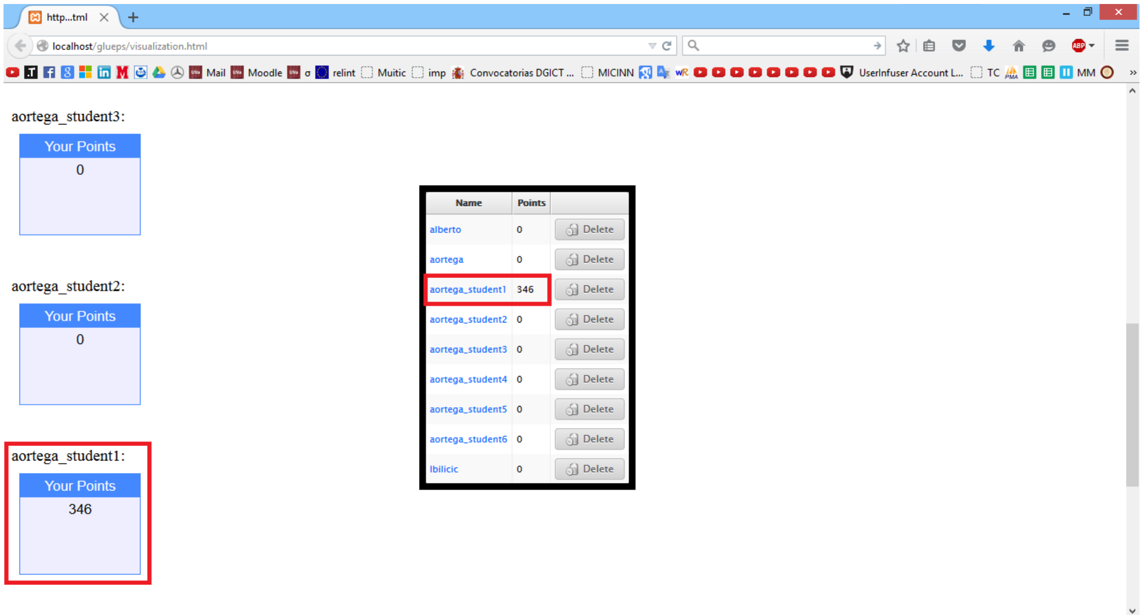

Figure 4.5: Left: The external web page where students can access to see their score. Right: The teachers' dashboard with the same score that students visualize.

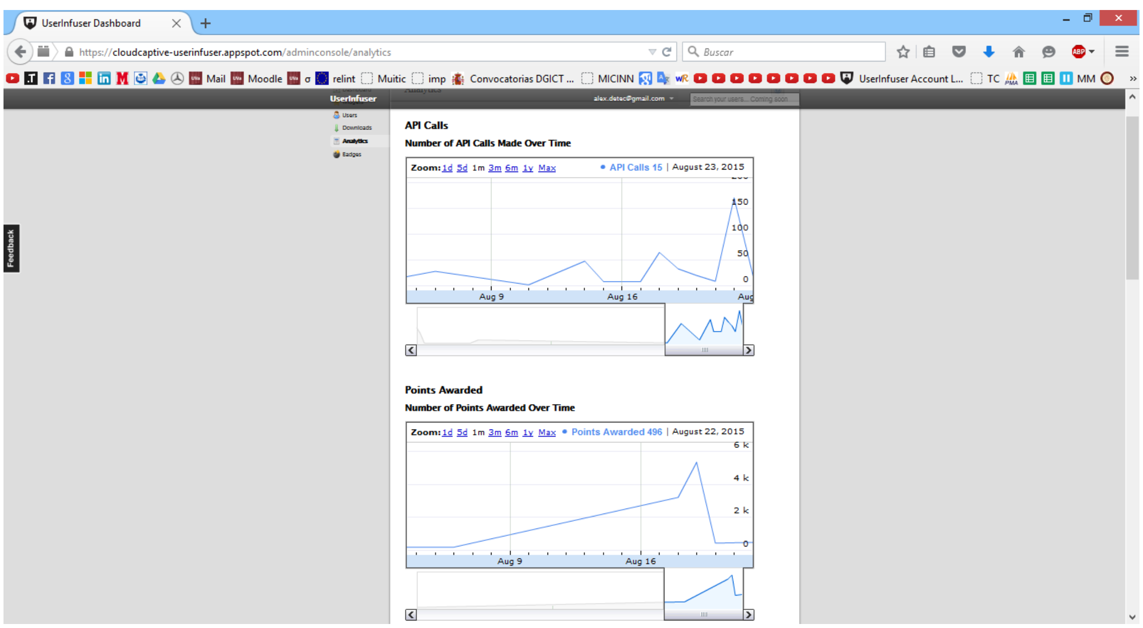

Figure 4.6: A couple of analytics supported by the gamification platform: number of API calls made and number of points awarded over the time.

the documents. Therefore, using the dashboard of the gamification platform, the teacher may, at real-time or later, reward students with points or punish them depending on their answers.

So far, we have seen in the screenshots the evolution of the score on the gamification platform dashboard which is only managed by the teacher. Students can also watch their score and a leaderboard on real time in an external web page created when the learning situation was deployed as shown in Fig. 4.5. As explained before, it seems promising the inclusion of scoreboards and showcases in different places such as VLEs. Nevertheless, the developed prototype is limited for this feature.

Finally, during the management or evaluation phase of the gamified learning situation, the teacher can make use of the available analytical system of the gamification platform. This system allows teachers to know the number of points awarded in total each day, the number of API calls, and other features of the gamified learning situation (see Fig. 4.6). Thus, the teacher can calculate statistics such as average points awarded to each student which may be useful for future gamifications.

4.4 Discussion and Chapter Conclusions

In this chapter we have presented the characteristics of a prototype based on the architecture and data model proposed to gamify learning situations. The prototype has been used to implement a proof of concept of the proposed architecture and data model. More concretely, the prototype has shown the capability of the architecture and the data model to implement a simple use case, where a teacher defines the kind of actions and rewards that are to be achieved by the students in an accross-spaces learning activity.

Since we have created a gamified learning situation with the developed prototype, we can provide initial evidence of the feasibility of the proposals presented in this dissertation. Nevertheless, some limitations have been identified both in the used gamification platform and in the developed prototype. On the one hand, the gamification platform limitations are fixed and a priori, and cannot be modified. However, as the implemented architecture allows to include other gamification platforms, some of these limitations could be solved if the new gamification platforms overtake such problems. The identified limitations of the implemented gamification platform are:

- Each registered email within the gamification platform can only deploy one learning situation. Thus, if a teacher wants to deploy various gamified learning situations with this platform during the same dates, she would have to use two different emails.

- Apart from the platform constrains, there are some gamification options that can be only carried out through the GUI of the gamification platform (e.g. remove participants or design badges). In case a teacher has to perform any of these actions, she must understand how GLUEPS-AR and the gamification platform work. Such new knowledge may involve an extra cognitive load that teachers could not afford. Even so, from the authors' point of view, the gamification functionalities presented in the prototype still ease the creation of gamified learning situations. For example, the automatic deployment of learning situation participants, the monitoring and rewarding automation, etc.

On the other hand, different from the limitations of the gamification platform, the limitations of the developed prototype can be corrected. These limitations are presented below as future work of the current developed prototype:

- As explained before, the visualization of rewards is fixed in a web page. The prototype is able to capture the information related to the rewards of each participant. A feasible improvement would be to let teachers choose which type and where students' rewards are placed (e.g. in a VLE, mobile application, etc.).

- In the present prototype, the conditions that have to be met to reward an action are configured as a parameter of the rewardable actions and are fixed. However, in order to make the system more flexible, it would be interesting if teachers could configure their own conditions. Then, they could associate these conditions to those students' actions in which the condition makes sense.

- The type of actions that can be monitored are limited and restricted to actions based on location and interaction within mobile AR browsers resources and VGs. To include gamification functionalities in other technologies that can be used in a learning situation, new monitoring adapters within the GLUEPS-AR adapters should be developed. In the same way as the types of actions, it would be interesting to increase the available types of rewards that can be used to gamify.

- This system follows a multi-multi environment integration approach, different platforms could be used to store and visualize the game mechanics. However, the current prototype can only integrate a unique gamification platform: Userinfuser. It seems desirable the addition of other gamification platforms to this system such as Mozilla Open Badges. Once different gamification platforms are integrated, it would be also interesting that the system was able to recognize the characteristics of each platform gamification. Thus, the system could offer to the teachers a specific form for each platform gamification to configure the rewarding and visualization properties (as currently GLUEPS-AR does for the different AR mobile browsers).

Finally, an evaluation with real teachers is also proposed as future work. Teachers should use either the presented prototype or another one to create a real gamified learning situation. Thus, the goal of this dissertation (i.e. help teachers in the gamification process of learning situations) could be better evaluated.

Chapter 5

Conclusions and Future Work

Resumen: El uso de gamificación en entornos digitales ha experimentado en los últimos años un crecimiento en diferentes dominios (Hamari, Koivisto, & Sarsa, 2014). Uno de esos dominios es la educación, donde la gamificación ha reportado beneficios como el aumento de la motivación de los estudiantes y su involucración en las actividades de aprendizaje. Sin embargo, sólo los profesores con conocimientos de programación o aquellos que recurren a programadores son los que realizan la mayoría de estas gamificaciones. La falta de un soporte tecnológico para gamificar es uno de los principales obstáculos para incluir los posibles beneficios de la gamificación en educación (Dicheva et al., 2015). Por eso, este trabajo propone el desarrollo de un sistema que pueda ayudar a los profesores a crear de una forma más intuitiva sus propias situaciones de aprendizaje independientemente de los espacios, recursos, herramientas y entornos utilizados. Para llevarlo a cabo, se ha definido un ciclo de vida de situaciones de aprendizaje gamificadas que ha permitido conocer los requisitos necesarios para el desarrollo de este tipo de sistemas. Así, partiendo del sistema GLUEPS-AR, se ha propuesto una arquitectura y un modelo de datos para el desarrollo de un sistema capaz de crear tales situaciones de aprendizaje gamificadas. Con el fin de comprobar la viabilidad del sistema propuesto, se ha desarrollado un prototipo implementando la arquitectura y modelo de datos propuestos. Este prototipo muestra cómo a través de una interfaz gráfica los usuarios de este sistema pueden configurar y automatizar los elementos de una gamificación. Como trabajo futuro, además de las proposiciones realizadas en cada capítulo, se propone un mayor desarrollo en el prototipo y una evaluación con profesores y situaciones de aprendizaje reales. Así, se podría evaluar con más profundidad si el objetivo de este trabajo se ha cumplido o no.

5.1 Conclusions

In recent years, the use of gamification in digital environments has experienced an increase in different domains (Hamari et al., 2014). One of these domains is education. Gamification in education has reported potential benefits such as increased student motivation and involvement to perform learning activities. However, only teachers with programming background and those who can draw upon programmers can benefit from such gamifications. The lack of proper technological support is one of the main obstacles to gamify educational environments (Dicheva et al., 2015). Existing developed gamification platforms have tried to solve this problem. Nevertheless, they present some limitations in the capabilities of the learning situations they are able to create, in the game design elements they are able to include, or both. As described in this work, current learning situations may involve different spaces and augmented Reality; may include third-party providers tools and can be deployed in different VLEs (Muñoz-Cristóbal et al., 2013).

Therefore, the main goal proposed for this dissertation is *"To help teachers create gamified learning situations that can make use of resources and tools frequently used in education and that may involve different physical and virtual spaces"*. In order to achieve it, the main goal was divided into two secondary goals:

- To model the lifecycle of gamified learning situations.

  Modeling the lifecycle of gamified learning situations has contributed to understand the actions that should be performed in each phase of this kind of situations. Since them can be collaborative and need monitoring, the proposed model has been based on the work of previous authors of the CSCL, LA and gamification fields. The main actions related to gamification are:

  1. The inclusion, configuration and deployment of the used game mechanics during the instantiation phase; and
  2. The capture and processing of students' actions, and the visualization of the game mechanics during the management phase.

  Thus, these resulting actions have led to the definition of the architectural components that must be included in a system able to create gamified learning situations: The proposed **monitoring adapters** should be able to *capture* the participants' actions that teachers defined as rewardable actions. Then, the **processing manager** should receive such information and *process* it. Processing means to analyze the value of the captured actions, check if they meet the conditions to be rewarded and if so, send the notification of rewarding to the gamification adapters. Finally, the **gamification adapters** are responsible of translating the information sent by the processing manager to the **gamification platforms** to store and *visualize* the game mechanics used.

- To automate, during the enactment, the gamification components included within learning situations.

  In gamification, game mechanics associated to structural gamification (e.g. rewards such as points) depend on students' actions within the activities. Real-time rewarding can provide students with timely feedback which can guide the students' actions and increase engagement. However, a manual rewarding process (i.e. capture, processing and visualize by teachers) can imply excessive work load for teachers and increase the rewarding latency since they have to monitor every student. An automatized rewarding system could provide students with a real-time recognition and and diminish teachers' workload. The proposed data model of gamified learning situation allows teachers to configure the aforementioned architectural components. Therefore, when students are performing the activities, these components can communicate among them and know which actions must carry out without the teachers' management. The exposed use case which utilizes the developed prototype shows how teachers can configure the components through the system interface. The implemented use case also shows how the teachers (and the students) can observe the evolution of the activity by simply observing a widget in a web-page. Teachers could also could check the students' scoreboards and analytics using the capabilities offered by the gamification platform. This connection between the gamification platform and the visualization of the students' performance by the teachers opens up new ways of connecting previous work done in learning analytics (Rodríguez-Triana, 2014) with the proposals presented in this work.

To carry this out, we first performed a literature review in the gamification domain. First, we analyzed what the gamification term means. There is a clearly stated accepted definition of gamification in literature: the use of game design elements in non-game contexts (Deterding et al., 2011). However, this definition can pose some questions on which it would be interesting to deepen.

- How many game mechanics should be included in a non-game context in order to gamify it? For example, are we gamifying an educational activity if we only add narrative story elements (which are considered for several author as game design element)? For this dissertation we have considered so. However, narrative story elements is not an exclusive mechanic from games, and it remains unclear whether adding a single game mechanic derives always in a gamified activity. Thus, we consider that future work on this topic could clarify this definition.

- Can some gamifications be more gamified than others depending on the number and type of used game mechanics? For our purposes, we considered the existence of different levels of gamification depending on specific game mechanics the gamification platforms can implement. Nevertheless, it seems interesting to determine if there are some game mechanics that can gamify more than others.

Most of gamification studies about the gamification outcomes of the students use to implement the same game mechanics (Dicheva et al., 2015). These game mechanics are leaderboards and game-like rewards such as points and badges. Thus, we believe that these game mechanics are able to affect the behavioral and physicological students' outcomes stronger than others. Following Kapp's gamification classification, these game mechanics produce structural gamification. In structural gamification, students must perform the same activities as if gamification was not. Then, they can watch the obtained rewards and scoreboards to check their progress, change the form they perform the activities, get motivated, etc. Thus, in this dissertation we have focuses on this kind of gamification.

5.2 Future Work

The performed feature analysis allowed us to analyze the gamification and activities that other platforms and similar systems are able to create. However, due to time constraints, the search of such platforms was limited. Thus, in case this work is continued, it is first proposed as future work a systematic literature review to ensure the novelty of the proposed system.

After the feature analysis, a prototype implementing the architecture and data model proposed has been developed. This prototype has demonstrated the feasibility of the proposal. However, as this work can be considered as an initial iteration of the research method adopted, it could not be assessed whether the system can meet the main objective of the work or not: to help teachers create gamified learning situations. Therefore, it is proposed as future work to conduct an evaluation with real teachers and the developed prototype, or a refined one. This evaluation could help to assess other aspects, such as the effort needed to create the situation, including the time devoted to do it, etc.

Nevertheless, help not only involves providing teachers with a tool, or decrease the time spent for creating a gamified learning situation. Initially, it was proposed to help teachers by recommending them which game mechanics they should include to unleash determined dynamics on students. Therefore, it is also proposed as future work an analysis of the existing literature on game mechanics-dynamics-learning mapping to include it in the developed system.

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Appendix A

Game Design Elements

Game design elements are the elements and features that make videogames enjoyable and fun to play, and which can be used to design the gamification of a learning situation. As we have seen in Chapter 2, different authors classify the existing game design elements in different ways. In this dissertation, we have considered that game design elements can be divided into game mechanics and game dynamics. This appendix exposes an analysis made in the literature of both game mechanics and dynamics.

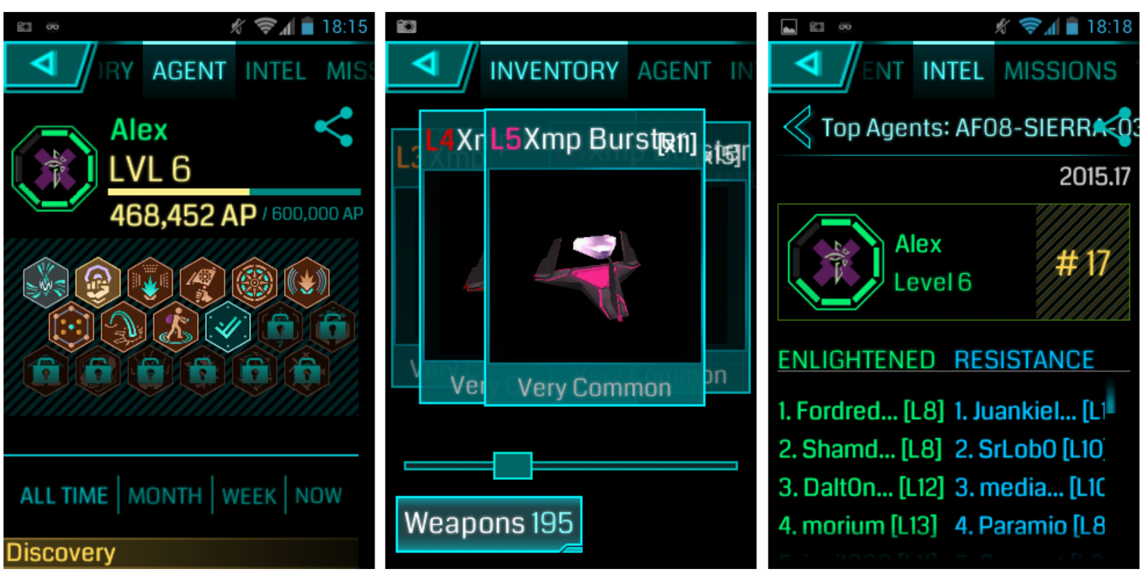

Figure A.1: Example of game mechanics in Ingress game. (left) Points, Level, Badges. (middle) Virtual goods. (right) Weekly Leaderboard.

1st Level Game Mechanics	Bunchball 2010	Zichermann 2011	Simoes 2013	Hamari 2014	Dicheva 2014	Dicheva 2015	Fitz-Walter 2015
Points	X	X	X	X	X	X	X
Levels	X	X	X	X		X	X
Medals, Badges, Trophies, etc.	X	X	X	X	X	X	X
Virtual Goods	X		X		X	X	
Leaderboard	X	X	X	X	X	X	X
Gifts	X		X				
Avatars		X				X	X
Quests		X					X
Progress Bar					X		
Story, Narrative				X			X
Virtual Currency							X
Mini-games							X

Table A.1: 1st level game mechanics found in gamification literature.

2nd Level Game Mechanics	Bunchball 2010	Zichermann 2011	Simoes 2013	Hamari 2014	Dicheva 2014	Dicheva 2015	Fitz-Walter 2015
Competitions	X						X
Customization				X		X	
Feedback					X	X	X
Game goals		X		X		X	X
Engagement Loops		X		X		X	
Rewards				X			X
Progress					X		
Accrual Grading					X		
Unlocking Content					X	X	
Onboarding		X				X	
Time Pressure						X	
Fantasy							X

Table A.2: 2nd level game mechanics found in gamification literature.

A.1 Game Mechanics

Game mechanics are the elements and rules that frequently appear in videogames that can be used to gamify and which can evoke emotional responses in players. In this dissertation, we have considered two types of game mechanics depending if they can interact directly with other elements of the activity or not. For example, points can be directly related to resources or actions of the learning situations (i.e. first-level game mechanics). However, there are some kind of game mechanics that cannot be themselves included as such into the activities that want to be gamified, although they can be used for the design (i.e. second-level game mechanics). For example, "feedback" is not included as an element into the activities, rewards, progress bars, and other first-level mechanics are the elements able to provide the feedback to the players.

In order to determine which first and second game mechanics have been used in other gamifications, an analysis in literature has been carried out. Such results are shown in Table A.1 (first-level game mechanics) and in Table A.2 (second-level game mechanics). Since in this dissertation first-level game mechanics are utilized to gamify, we define below the most used game mechanics. An example of these mechanics in a multi-space game (i.e. Ingress[1]) is shown in Fig. A.1.

Points is a game design element that provide granular and timely feedback in a gami-

[1] *https://www.ingress.com/*

fied system (Suh et al., 2015). It is a way to value, reward and track every move that players make (Zichermann & Cunningham, 2011). Different categories of points can be used to drive different behaviors (Bunchball, 2010). Based on their experience, Zichermann and Cunningham (2011) identified the five most used point system types: experience, redeemable, skill, karma and reputation points.

Levels serve as a marker for players to know where they stand in a gaming experience over time (progress) (Zichermann & Cunningham, 2011). We can distinguish two types of levels. On the one hand, they can be earned by the player as point thresholds that should afford a certain amount of respect and status (Bunchball, 2010). On the other hand, they can be also utilized as a difficulty mark of the activity to be chosen by the player.

Badges are similar to achievements, trophies, ribbons, challenges, etc. They mark the completion of challenges or goals and the steady progress of play within the system (Zichermann & Cunningham, 2011). These task-reward systems usually reward the player with points, unlock content or simply exist as status symbols (Fitz-Walter et al., 2011; Dicheva et al., 2014) in a visible way (Bunchball, 2010). Previous studies reveal that they are a method to motivate students and affect the behavior of students even when they have no impact on the grading (Hakulinen et al., 2013). Finally, some achievements can been designed as hidden; they are awarded by surprise when some special conditions are met (Dicheva et al., 2014) which can also stimulate players to keep playing in a different way.

Virtual Goods are non-physical, intangible objects that have influence in the activity gameplay (Bunchball, 2010). Players can obtain and use them by interacting with the other mechanics or components of the activity such as redeeming points.

Leaderboards are used to track and display desired actions or parameters (e.g. rewards or times), using competition to drive valuable behavior (Bunchball, 2010). The purpose of a leaderboard is to make simple comparisons (Zichermann & Cunningham, 2011). They can be used to compare points, levels, badges and the rest of the mechanics owned by players. Literature also argues negative effects using this mechanic, such as excessive competitiveness if they are not well implemented.

A.2 Game Dynamics Description

Game dynamics are players' feelings and behaviors created by their interaction with the game mechanics. Literature describes different types of game dynamics which are explained in this subsection. In order to identify the dynamics considered by other authors in the gamification field, an analysis has been carried out. The result (see Table A.3 shows that the most considered dynamics are: reward, status, achievement, self-expression, competition and altruism.

Game Dynamics	Hunicke 2004	Bunchball 2010	Simoes 2013	Arnab 2014	Suh 2015	Fitz-Walter 2015
Reward		X	X	X	X	
Status		X	X	X	X	
Achievement		X	X		X	
Self-expression		X	X		X	
Competition		X	X	X	X	
Altruism		X	X		X	
Curiosity	X			X		X
Cooperation	X			X		X
Fantasy	X					
Pleasure	X					

Table A.3: Game dynamics found in gamification literature.

Reward consists on obtaining points or receiving any kind of tangible items which will be at users' disposal (Suh et al., 2015). A reward, tangible or intangible, is presented after the occurrence of an action (i.e., behavior) with the intent to cause the behavior and desire to occur again (Suh et al., 2015). With gamification, the primary reward mechanism is through earning points (Bunchball, 2010; Suh et al., 2015), but obtaining virtual goods, leveling up, and even completing achievements also satisfy this desire (Bunchball, 2010).

Status is a way of recognition, fame, prestige, attention and, ultimately, the esteem and respect of others (Bunchball, 2010). It represents levels labeled according to skills or contributions which enhances the desire of increasing your level (Suh et al., 2015). The primary status mechanism is a level system (Bunchball, 2010; Suh et al., 2015).

Different from reward, **achievement** consists on being rewarded for the completion of a specific goal (Suh et al., 2015). The primary achievement mechanism are badges (Bunchball, 2010; Suh et al., 2015).

Self-Expression is a human desire to show off a sense of style, identity, and personality (Bunchball, 2010; Suh et al., 2015). In a virtual gamification, it can be expressed by using virtual items or virtual goods. For example, a person's avatar can often serve as a point for expression (Bunchball, 2010).

Some people gain a certain amount of satisfaction by comparing and **Competing** their performance to others (Bunchball, 2010; Suh et al., 2015). Individuals are motivated to achieve greater performance in a competitive environment (Suh et al., 2015). It also increases the perception of interacting with others (Suh et al., 2015). The use of leaderboards is a way to display these competitive results (Bunchball, 2010; Suh et al., 2015).

Altruism is a practice of gift-giving. This behavior is a strong motivator for fostering relationships (Bunchball, 2010) Some social games include this dynamic. When someone receives a gift, it pulls her back into the application to redeem it, so it serves as a powerful retention element as well (Bunchball, 2010).