Computers & Education 63 (2013) 380–392

Contents lists available at SciVerse ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Gamifying learning experiences: Practical implications and outcomes

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ARTICLE INFO

Article history:
Received 31 July 2012
Received in revised form
20 December 2012
Accepted 23 December 2012

Keywords:
Gamification
Games-based learning
Computer game
Game mechanic
Motivation
Engagement
e-learning

ABSTRACT

Gamification is the use of game design elements and game mechanics in non-game contexts. This idea has been used successfully in many web based businesses to increase user engagement. Some researchers suggest that it could also be used in web based education as a tool to increase student motivation and engagement. In an attempt to verify those theories, we have designed and built a gamification plugin for a well-known e-learning platform. We have made an experiment using this plugin in a university course, collecting quantitative and qualitative data in the process. Our findings suggest that some common beliefs about the benefits obtained when using games in education can be challenged. Students who completed the gamified experience got better scores in practical assignments and in overall score, but our findings also suggest that these students performed poorly on written assignments and participated less on class activities, although their initial motivation was higher.

1. Introduction

Since the 1970s and 80s, video games have been increasing their popularity over time as a form of entertainment. Firstly oriented towards a male audience, the video game industry has made big efforts to expand its market and reach more kinds of people, especially women and families. But it was not until the most recent years that the industry achieved this objective, with two clear examples, the Wii console system, and the Facebook social games, both with millions of users around the world. Currently, video games are the most powerful entertainment industry in economic terms,[1] and are also considered an incipient form of art.[2]

Education researchers have viewed this kind of entertainment with great interest. Video games are interactive activities that continually provide challenges and goals to the players, thus involving them into an active learning process to master the game mechanics (Koster, 2005). At the same time, video games provide a fictional context in the form of narrative, graphics and music, which if used appropriately, can encourage the interest of players on non-gaming topics, like for example, history (Watson, Mong, & Harris, 2011). Due to this potential, a lot of work has been done trying to unveil how video games could be used successfully with educational purposes. In the 1980s Malone (1980) and Bowman (1982) theorized about what makes computer games so appealing to players, and how those aspects could be applied in education to improve student motivation and engagement. Over time researchers conducted many theoretical and empirical studies on this subject. These studies have unveiled many potential advantages of videogames in education like immediate feedback, information on demand, productive learning, motivating cycles of expertise, self-regulated learning or team collaboration (Gee, 2003; Rosas, Nussbaum, & Cumsille, 2003); but also some issues related to educative content, learning transfer, learning assessment, teacher implication and technological infrastructure (Facer, 2003; Squire, 2002, 2003). Recently Connolly, Boyle, MacArthur, Hainey, and Boyle (2012) presented a systematic literature review on games-based learning and serious gaming focusing on positive outcomes. They also stress the necessity of more rigorous evidence of games' effectiveness and real impact.

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[1] Factbox: A look at the $65 billion video games industry. June 6, 2011. Reuters. http://uk.reuters.com/article/2011/06/06/us-videogames-factbox-idUKTRE75552I20110606.
[2] Art-s in Media. http://arts.gov/grants/apply/AIM-presentation.html.

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http://dx.doi.org/10.1016/j.compedu.2012.12.020

Due to mentioned issues, some researchers do not focus on using videogames to educate, but on exporting good aspects of video games to non-gaming educative contexts. This concept, which is not exclusive of education, is commonly called 'gamification'. Some researchers generically defined it as the use of game design elements and game mechanics in non-game contexts (Deterding, Dixon, & Khaled, 2011), although this broad definition has been further refined to reflect the most common objective of gamification: increase user experience and engagement with a system. Another relevant fact is that, like videogames, gamification is still based on technology, and it's almost always applied on desktop, web or smartphone applications. Attending to these facts, it could be more narrowly defined as incorporating game elements into a non-gaming software application to increase user experience and engagement. This last definition is the one we will use for the rest of the paper.

Gamification has been incorporated with commercial success into platforms,[3] especially social ones, as a way to create narrow relationships between the platform and the users, and to drive viral behaviors on them to increase platform popularity. This success has made some researchers theorize that it could also be used in education as a tool to increase student engagement and to drive desirable learning behaviors on them (Lee & Hammer, 2011). Attending to its technological nature, one of the fields where gamification may have a greater impact is online learning. Its potential benefits may address well-known issues as, for example, the lack of student motivation due to the limited capacity of interaction with teacher and classmates (Liaw, 2008). In addition, the monitoring and communication infrastructure of e-learning platforms provides the necessary tools to incorporate different gamification mechanisms and to measure their usage by students.

This paper will make a contribution to the empirical evidence in the field by designing, implementing and evaluating a gamified learning experience in tertiary education. Our research tries to bridge the gap between theory and practice and study the design and consequences of applying gamification in a real educational setting. The rest of the paper is structured as follows: Section 2 presents previous research of gamification in education. Section 3 presents a theoretical analysis of videogames and motivation. Section 4 presents the system's design and Section 5 briefly outlines the technological architecture. Section 6 presents the experimental design. Section 7 presents quantitative and qualitative results and discussion on those results. Finally conclusions and future research lines are outlined in Section 8.

2. Previous research

While some researchers are already working on it, currently there is still little work on this subject. Muntean made a theoretical analysis of gamification as a tool to increase engagement in e-learning platforms (Muntean, 2011). Based on Fogg's Behavior Model, the author states that gamification mechanics can be used to motivate and trigger desired behaviors on students. Although he provides a list of gamification elements explaining how they could be included in an e-learning course, there is no empirical research so, in our opinion, more work will be required to give an implementation and obtain evidence about its effect on students.

Silva proposes another list of gamification elements, focusing specifically on social game mechanisms, that could be included in e-learning courses to increase student motivation by means of new interaction mechanisms with classmates (Silva, 2010). Customization, community interaction or leaderboards are some of the proposed mechanisms, but the author provides little guidance of how to apply them on education, so more work is needed in this area.

Recently Simões, Díaz & Fernández (2013) presented a social gamification framework for http://schooools.com, a social learning environment, which "aims to assist educators and schools with a set of powerful and engaging educational tools to improve students' motivation and learning outcomes"(p. 3). This framework enables teachers to deliver contents fitted to learning contexts and students' profiles by choosing the appropriate social gamification tools, based on social games' mechanics and dynamics. These authors also present a scenario describing how a specific mechanic can be integrated using a point-based reward system, thus demonstrating the extensibility of the framework, but there is no empirical evidence about the effectiveness of this approach.

One of the few empirical researches on this subject is the master's thesis "Game mechanic based e-learning" (Gåsland, 2011). In her work, Gaasland presents a detailed experiment in which she developed a web platform for a gamified e-learning experience and evaluated it with a university class. The platform served as a collaborative database where students could create and answer questions, using it as an alternative way to study and revise topics. Apart from the collaborative aspect, the only gamification mechanism is Experience Points, a classic video game mechanic used to keep track of progression. Results suggest that the platform is somewhat motivating, but that much more research is needed to test other gamification mechanisms and their combinations.

Our objective is to continue working on the line of the previous papers from an empirical point of view, studying also the motivational impact of different gamification mechanisms. For that, we have created an e-learning gamification system that includes a limited set of those mechanisms, and we have tested it on a university course, obtaining qualitative and quantitative data from the students. This contribution will lead to a better understanding of the effects of gamification on e-learning.

3. Videogames and motivation

To create a gamification system that increases student motivation it is necessary to focus on the fundamental elements that make videogames appealing to their players. According to Lee and Hammer (2011), games are motivating because of their impact on the cognitive, emotional and social areas of players; and so, gamification in education should also focus on those three areas.

In the cognitive area, a game provides a complex system of rules along with series of tasks that guide players through a process to master those rules. These tasks are designed as cycles of expertise (Gee, 2003). A cycle consists of a series of short-term tasks which players repeatedly try to complete in a try and fail process until the necessary skill level is acquired. When the player is involved in this learning process, games try to assure that players always know what to do next, and that they have the necessary knowledge to do it. To make the learning process customizable, task sequences are usually non-linear, and players have a certain degree of freedom to choose which tasks to accomplish depending on skill and personal preferences.

[3] A notable example is Badgeville. http://www.badgeville.com/.

- …
- Module 2 – Word Processors
    - Challenge 1 – Word Intermediate
        - Level 1 – Titles and Styles
        - Level 2 – Bullets
            1. Start a bulleted list
            2. Change the style of the newly created bulleted list
            3. Justify all the text except the main title
            4. …
        - Level 3 – Table of contents and headings
    - Challenge 2 – Word Advanced
        - …
- Module 3 – Spreadsheets
    -

Fig. 1. Sample of hierarchical tree for course 'Qualification for users of ICT'.

The impact on the emotional area works mainly around the concept of success and failure. On one hand, when players complete tasks they are expected to have positive emotions by their mere fact of overcoming difficulties. Games try to assure and increase those feelings with reward systems that give immediate recognition to players' success, awarding them with points, trophies or items on task completion. On the other hand, when players fail, they are expected to feel anxiety. While some degree of anxiety is acceptable, it is not desirable that it transforms into frustration. To avoid that, sequences of tasks are carefully designed to fit players' skills at any level, and include low penalties on failure to promote experimentation and task repetition. If the difficulty of tasks is correctly balanced, it can drive the players to a flow state which is highly motivating (Csikszentmihalyi, 2008).

When multiple players interact through the game, these interactions have impact on players' social area. Videogames offer a wide range of multiplayer interaction mechanisms which are integrated in the rules of the system. These mechanisms make it possible for players to cooperate helping each other towards a common goal, to compete trying to impair other players or to perform better than them, or just to interact socially by talking, flirting, trading or gifting for example. All these kinds of interaction let players build different in-game identities taking meaningful roles and obtaining recognition from other players (Lee & Hoadley, 2007).

All these three areas (cognitive, emotional and social) seem to be the base for player motivation, but their limits are blurry and game mechanics usually cover more than one at the same time. For example, many items that are awarded to players on success are just keys to new cycles of expertise that increase game complexity and difficulty, impacting both emotional and cognitive areas. Social area is always mixed with cognitive area, when a task must be solved by means of player cooperation or competition; or with emotional area, when rewards systems have an impact on players' social status.

The main objective behind gamification in education is to apply some of these ideas when designing educative initiatives and their contents in an attempt to make them more motivating. The fact that technology is necessary to implement most of the exposed mechanisms makes e-learning platforms an ideal environment for experimentation.

4. System design

According to elements exposed in the previous section, we have designed a gamified educative experience in which some of those elements are adapted and applied on an e-learning platform used as a tool in a university course. The course "Qualification for users of ICT" is a transversal course in which students of different grades learn how to effectively use common ICT tools. The course is aimed at promoting basic ICT competence at user level for students. It is inspired in the well-known ECDL (European Computer Driving License),[4] a de-facto vendor-independent standard in Europe for ICT literacy, with millions of certified people. Syllabus includes modules on general ICT knowledge, basic use of operating system, word processor, spreadsheet, presentation software, database and communications skills with web browsers and email. The course has optional exercises designed to improve the skills of students so that they perform better on final exams. These exercises are usually downloadable from a Blackboard e-learning platform as PDFs. Instead of providing them as downloadable text files, we have created a Blackboard plugin which provides the same exercises in a gamified way. The main objective of this plugin is to increase student motivation towards completing optional exercises through the use of rewards and competition mechanisms. In the following sections we describe the design of this plugin.

4.1. Cognitive area

The first step was the design of the cognitive area of the experience. In this case, the system of rules in which students must obtain skills is provided by the ICT tools used in the course, and the tasks that guide the player in the tool mastery process are the optional exercises. Due to our research objectives, we decided that the gamification impact on this aspect should be limited in order to keep gamified tasks as similar as possible to traditional optional exercises. Our solution was to create a hierarchical tree following the course topics and optional exercises structure (Fig. 1). First level of the tree matches subject's list of topics; second level matches optional exercises for each topic, called 'challenges'; third level matches specific tasks in each challenge, called 'trophies' or challenge activities; and fourth level matches specific

[4] http://www.ecdl.com/.

steps in each stage that provide students with a detailed description of the work they have to do in order to obtain the trophy. Students can freely access any topic and its challenges once it has been introduced in lectures. Trophies in a challenge are designed to be increasing in difficulty and based on the previous ones, so they are sequentially unlocked as the student completes them. In order to make this hierarchy clear for the students, we included two challenges per topic – intermediate and advance – and at most four trophies per challenge – copper, silver, gold and platinum, each element with an appropriate visual representation (Fig. 2). Although these tasks are presented in video game-like fashion, they are exactly the same as their traditional counterparts presented in PDF format.

Another important element of this area was task evaluation. Traditional exercises were not evaluated at all, but in order to be able to reward task completion, we required an evaluation mechanism. An ideal mechanism would be integrated in the e-learning platform, making it possible for student to auto-evaluate their tasks. Nevertheless, this is not always possible, as in our case, where exercises had to be done using external software. The solution we came through was to use screenshots as evaluation mechanism, as we thought that it was simple for students to capture and upload screenshots of their work while they were completing a task, and that those screenshots could provide enough information for teachers to evaluate if the task was correctly completed or not. The problem with this solution is that if students needed to wait for teacher to evaluate their work, it would be impossible to give immediate feedback on task completion in the form of a reward (more about rewards in the following section). To avoid this, we decided to immediately accept any uploaded screenshot as correct, leaving the evaluation as a verification mechanism to see if students were being honest and if their work was correctly done. In future initiatives we may consider computer-based testing (Santos, Hernández-Leo, Pérez-Sanagustín, & Blat, 2012; Santos, Pérez-Sanagustín, Hernández-Leo, & Blat, 2011) to overcome these problems.

4.2. Emotional area

Next step was to design how to impact on the emotional area of students. Our proposal was to include a virtual reward system that could create positive emotions on task completion, thus motivating students to complete more tasks. According to Wang and Sun's work on game reward systems, there are eight forms of rewards: score systems, experience points, items, resources, achievements, instant feedback messages, plot animations, and game content (Wang & Sun, 2011). Most of these rewards cannot be easily incorporated in gamification systems. The lack of virtual worlds, avatars and stories make it difficult to include experience points, items, resources, plot animations or unlockable game content. Instant feedback messages seem to be great to create positive emotions, but such a reward system is not feasible because it would require to be integrated within the external software used by students to complete tasks. After examining the remaining reward systems, points and achievements, we decided that achievements were the most appropriate form of reward for us. According to Wang's definition, "achievement systems consist of titles that are bound to player accounts; users collect them by fulfilling clearly stated conditions" (p. 4). In our gamified experience students will have to complete tasks in order to obtain achievements. Although a score system may also fit in our design, we left it out to keep design as simple as possible.

Achievements may generate a wide range of positive emotions. One possible emotion is related to the fact of being immediately rewarded on task completion, as students will feel that they are performing well. To increase this feeling, we decided to represent some special achievements as medals, a typical representation of excellence (Fig. 3). Another one is related to the fact of achievements being collectables. Non-completed achievements are shown to the player as a list of tasks to perform, with an empty space for the corresponding medal. Players motivated by collectables will be tempted to continue working in order to get all medals. Finally, some achievements have been designed as hidden; they are awarded by surprise when some special conditions are met. In addition to being surprised with an award, these achievements may also serve to promote exploration of system features in order to discover the secret medals.

4.3. Social area

The final design step is related to the social area of the system. As previously exposed, there are different ways of student interaction: cooperative, competitive and social. Due to the individual design of course exercises, cooperative interaction didn't have sense in our system. Between the remaining two, we decided to include only competitive mechanisms to be able to study their effect over students in isolation;

Fig. 2. Screen capture showing a challenge and its four trophies. Copper, silver and gold trophies are completed, while platinum trophy is unlocked but not yet completed (in Spanish). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 3. Sample of some special achievements represented as medals.

thus leaving social mechanisms for future works. The most basic mechanic of competition in many videogames is a leaderboard or ranking, so we opted to include this mechanic in our system. Usually leaderboards are score based, but due to the lack of a score system in our design we used achievements instead, ranking players by the number of achievements they own (Fig. 4). This leaderboard let students compete to obtain higher ranking by completing more exercises and by participating in the overall experience. This could be a source of motivation for competitive students. Additionally two other competition mechanisms are provided. One of them lets a player view a comparison between his achievement list and the achievement list of any other classmate. Comparison view could drive more direct competition between two specific players who are trying to beat each other. The other included mechanism shows a list with all the achievements in the platform, along with the percentage of total users who own it. This lets players challenge themselves to obtain the most exclusive achievements.

5. System architecture

In this section we will briefly describe system architecture. While "Qualification for users of ICT" course used Blackboard 8 (BB8) as e-learning platform for online content, custom plugin support was made available only since Blackboard 9 (BB9) version. We solved this problem by implementing a gamification plugin for the BB9 platform and deploying it on a parallel course to the BB8 one. Students could use the same login credentials in BB8 and in BB9 platforms; traditional content was available in the former and gamified content in the latter.

Several technologies were used to implement the system (Fig. 5). Blackboard 9 plugins are JSP web applications that can access student data, and in consequence, don't require user authentication. Although the e-learning platform database could supposedly be used to store plugin data, several problems were found at developing time, mainly related with the amount of documentation available, so we decided to explore alternative solutions. We decided to create a cloud-based web service in Microsoft Azure platform linked to an SQL Azure database. This service was consumed from client-side using AJAX. It was designed using the RESTful principles, and programmed in C# using Windows Communication Foundation. Lastly, Amazon EC3 cloud based persistent storage services were used to store screenshots and user avatars.

6. Experimental design

In order to assess the effectiveness of the gamified approach and to evaluate the attitude of students we designed an experiment for two different groups of the course "Qualification for users of ICT" (6 ECTS, 150–180 h of student work). This course is based on the ECDL certification syllabus and has the following modules:

1. Introduction to the computer, the operating system, networks and communication.
2. Word processor
3. Spreadsheets
4. Presentation software
5. Databases

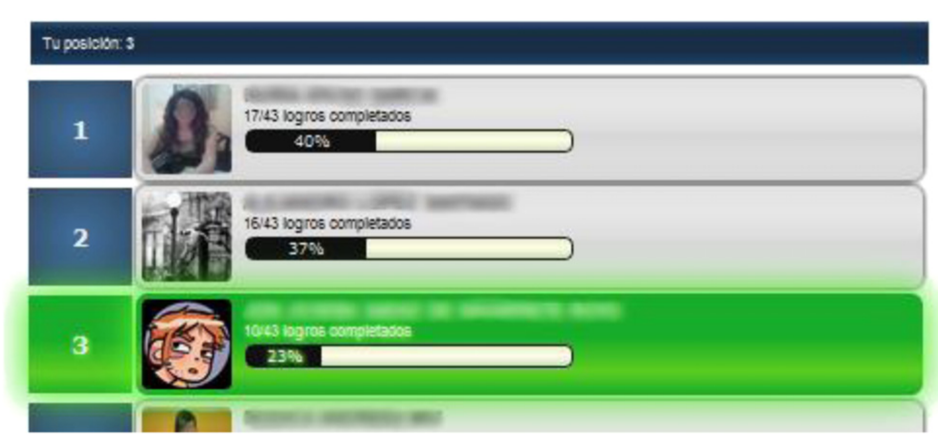

Fig. 4. Leaderboard sample, each row shows player's photo, ladder position, number of achievements, and percentage of total achievements.

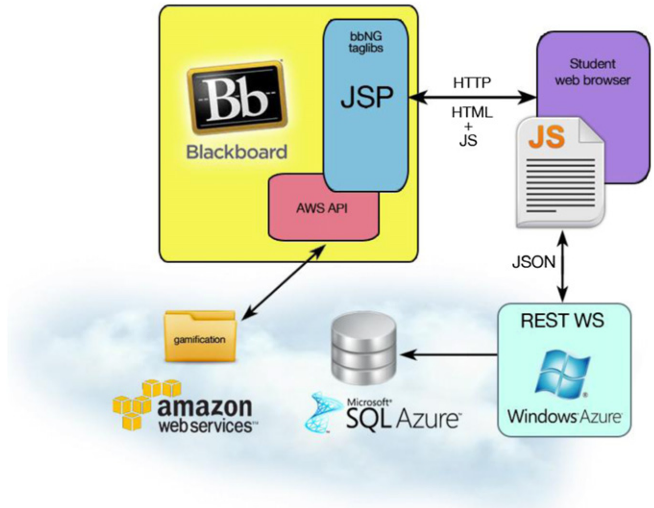

Fig. 5. System architecture diagram.

The final score of the course is computed based on the following evaluation items:

- Initial activity (5%).
- Midterm assignment (30%)
- Final assignment (30%)
- Final examination (30%)
- Participation (5%)

The *initial activity* (week 1) is designed to introduce the course to the students, to get them used to the course stuff and class dynamics, including the e-learning platform, and also to collect basic information about them. Students are asked to complete their personal profile, fill two surveys about their knowledge and their usage of ICT, and also to complete a short interactive test to assess their initial knowledge about modules 2–6 (word processor, spreadsheets, presentation software and databases). Questions in this test cover just basic initial topics about each module but they turn out to be interesting for two reasons: firstly, students get a first glimpse of the overall contents and skills required to pass the course, and secondly, initial scores for each module are collected given useful information to both student and teacher. Teachers consider that this score is an indicator of the initial motivation of the student instead of being a precise score of her initial knowledge. Activities are designed to motivate the student to participate and complete the course. In the *midterm assignment* (week 10) students have to hand in two exercises which correspond to modules 2 (word processor) and 3 (spreadsheets). On the *final assignment* (week 14) students submit their exercises of modules 4 (presentation software) and 5 (databases). The *final examination* (week 15) is a written test comprised of multiple choice as well as open-ended questions. Finally students can get up to a 5% of the final score based on their *participation* on the activities that take place in classroom as well as on the virtual classroom (e-learning platform). This score is computed semi-automatically taking the number of interactions on the e-learning platform (posts in the forum, elements opened, activities completed, messages read, etc… and also challenges, trophies, achievements, leaderboard, etc…) and a subjective assessment of the lecturer based on the student attendance and participation in classroom. With this system of evaluation it is possible to have 7 scores per student (initial activity, word processor, spreadsheet, presentation software, databases, final examination and participation) as well as the final score. All scores can be used to compare the performance of different groups. None of the evaluation instruments was gamified.

During the spring semester the course “Qualification for users of ICT” is given to two distinct groups. As it is a transversal course, it is offered to a wide range of students majoring different specialties. The *control group* consists of 1st and 2nd year university students (freshmen and sophomores) majoring construction engineering, nursing, tourism, infant education, primary education or business administration and management. 80 students enrolled initially and 73 completed at least one assignment so that they have a final score. The *experimental group* consists of 1st year university students (freshmen) majoring economics, business administration and management, accounting and finance, or economics and international business. 131 students enrolled initially and 123 completed at least one assignment so that they have a final score. Both groups have separated spaces in the virtual classroom so that a student of one group does not know about the activities on the other group. Groups are also physically distant as teaching takes place in different campuses and cities. The same instruments and evaluation criteria were used to compute scores of students of both groups. The experimental and control groups were chosen randomly. Unfortunately we were not able to assign individual students to each group as they freely enroll in the group that they prefer. This decision is mostly made based on their major as the faculties/buildings schedule the groups for their students.

The gamified version of the course includes 36 challenge achievements (grouped in 9 challenges/activities), from which students get trophies after completion, and 7 participation achievements from which participants get medals. All content challenges were created using exactly the same contents of the activities available in the traditional non-gamified version of the course. Students in the experimental group have access to both versions of every activity. Traditional activities are delivered using PDF files. Students of the experimental group received an introduction of 1 hour to the gamification plug-in by the teacher. After that, they have the opportunity to decide freely which set of activities they prefer to use and also to combine them as they want. If they want to use the gamified version they are just asked to register and upload their own avatar (a picture) the first time they connect. On first connection students are shown an introductory screen with a text based tutorial that highlights plug-in features and explains how to use it. Technical support was also available during the course.

The plugin conveniently registers the activities of students on the gamified version. 58 students of the experimental group registered to use the gamified version of the course. 27 students got 8 or more trophies and medals (i.e. completed 8 or more achievements). Teachers indicated that 8 is the minimum number of achievements that a student must complete to consider that she followed the gamified version. This is just to be sure that she completed activities of at least 3 different modules, but it will also offer a new dimension for analyzing the results as it permitted researchers to distinguish between those students who followed the gamified experience and those who did not. The plugin also permitted getting information on academic results as well as quantitative data and qualitative impressions about students' interaction both with gamified activities and with traditional courseware. The decision to made participation on the gamified experience optional was partly based on this but also on institutional requirements. Making participation mandatory would have supposed to do so for all students in all groups thus hindering experimental design.

7. Results

All the experiments and grading were conducted during the 2011/2012 spring semester. Outcome data collected of the experimental and control group is presented and discussed in this section. It must be borne in mind that teachers provided a grade for each evaluation item of each student along with a final mark for the whole learning experience. Students' opinions were also appraised in an attitudinal survey. All grades were normalized in the range 0–100 for statistical analysis.

7.1. Achievement of students

Independent-2-sample *t*-tests indicate that there is no significant difference in the initial knowledge of students in each of the four modules that was assessed (Table 1). Post-test results suggest that there is significant difference in six scores (Table 2). Students of the experimental group get scores that are significantly higher in the initial activity ($p = .004$) and also in the practical exercises about spreadsheets ($p = .007$), software presentation ($p = .000$) and databases ($p = .000$). On the contrary, students of the experimental group get significantly lower scores on the final examination ($p = .006$) and on the participation score ($p = .000$). Finally there is no significant evidence to support that the experimental group performs better on the exercise on word processing ($p = .090$) and on the final score ($p = .090$). Results of the most significant scores are also presented graphically in Fig. 6.

One-way analyses of variance (ANOVA) are used to determine the existence of significant differences considering three groups: the control group, the experimental non-gamified group, the experimental gamified group. Results (Table 3) are similar to those obtained distinguishing just two groups. The difference in the final score is now statistically significant in at least one of the groups. Confidence intervals (Fig. 7) show this graphically and suggest that students who get 6 or more achievements in the gamified system also get significantly higher final scores. Interval plots for the final examination score (Fig. 8) and for the participation score (Fig. 9) also suggest that the non-gamified experimental group have significantly lower scores than the other two groups and consequently there is no evidence that can confirm that the gamified experience yields worse results in written examinations or somehow prevents students from participating in class activities.

Students on the experimental group performed better on all the items that were concerned with practical application of concepts. On the other hand students in the experimental group performed lower than the control group on the written examination and participation. We think that such differences may be caused by the distinctive nature of the elements being assessed on these items and by the kind of learning fostered by each instrument. In the written examination students are asked mainly about concepts and about the relation of these concepts to practice. On all other evaluation items (except participation) assessment is based on competencies and students are required to know how to complete different tasks using a given application. Considering the results obtained, we can argue that gamified activities help to develop practical competences but somehow they also hinder the understanding of underlying theoretical concepts in contrast with traditional courseware. This conclusion was also drawn by previous work and it has even been identified as a trend by Ke's (2009) meta-analysis who suggested that learning games foster high-order thinking more than factual knowledge.

As for participation, this item was assessed mostly in an objective way based on the number of interactions with the learning platform, contributions to forums and other participative media, and attendance and exercises completed both online and in the classroom. It is tempting to argue that the lower marks got by students in the experimental group are due to the alienating nature of videogames. This is aligned not only with popular culture but also with heideggerian philosophy on alienation through technology. Defendants of this standpoint will argue that the gamified activities while fostering competence acquisition also split in or separate students from reality thus reducing their overall interaction with other students and systems. It is worth mentioning that Heidegger (1977) perspective is that technology is not alienating *per se*, but only when *enframing* (i.e. when the other is treated as an object, rather than as a subject) occurs as

Table 1
Scores in the initial activity for each module. Significance was computed using independent-2-sample *t*-tests.

Evaluation item	Group	*n*	Mean	Std dev	Significance
Word processor	Control	62	44.13	17.68	$F = 2.20$
	Experimental	111	49.92	16.53	$p = .141$
Spreadsheet	Control	62	53.32	17.68	$F = 0.62$
	Experimental	111	56.27	12.95	$p = .432$
Presentations	Control	62	44.52	13.14	$F = 0.49$
	Experimental	111	46.54	12.17	$p = .487$
Databases	Control	62	52.76	17.19	$F = 1.36$
	Experimental	111	56.01	17.75	$p = .244$

Table 2
Final scores for the experimental and control groups. Significance was computed using independent-2-sample *t*-tests.

Evaluation item	Group	*n*	Mean	Std error	Std dev	Significance
Initial activity	Control	73	77.29	2.41	20.63	$F = 8.43$
	Experimental	123	88.46	2.59	28.75	$p = .004$
Word processor	Control	64	56.33	2.34	18.73	$F = 2.90$
	Experimental	113	64.01	2.63	27.98	$p = .090$
Spreadsheet	Control	64	62.70	3.21	25.67	$F = 7.48$
	Experimental	110	73.94	2.52	26.40	$p = .007$
Presentations	Control	66	64.59	1.52	12.38	$F = 178.48$
	Experimental	110	89.86	1.15	12.01	$p = .000$
Databases	Control	65	40.25	2.84	22.86	$F = 56.12$
	Experimental	106	69.65	2.53	26.09	$p = .000$
Final examination	Control	68	64.12	1.66	13.67	$F = 7.78$
	Experimental	106	58.05	1.38	14.21	$p = .006$
Participation	Control	73	86.53	2.42	20.67	$F = 97.47$
	Experimental	123	48.13	2.63	29.15	$p = .000$
Final	Control	73	56.27	2.17	18.58	$F = 2.90$
	Experimental	123	61.57	2.02	22.41	$p = .090$

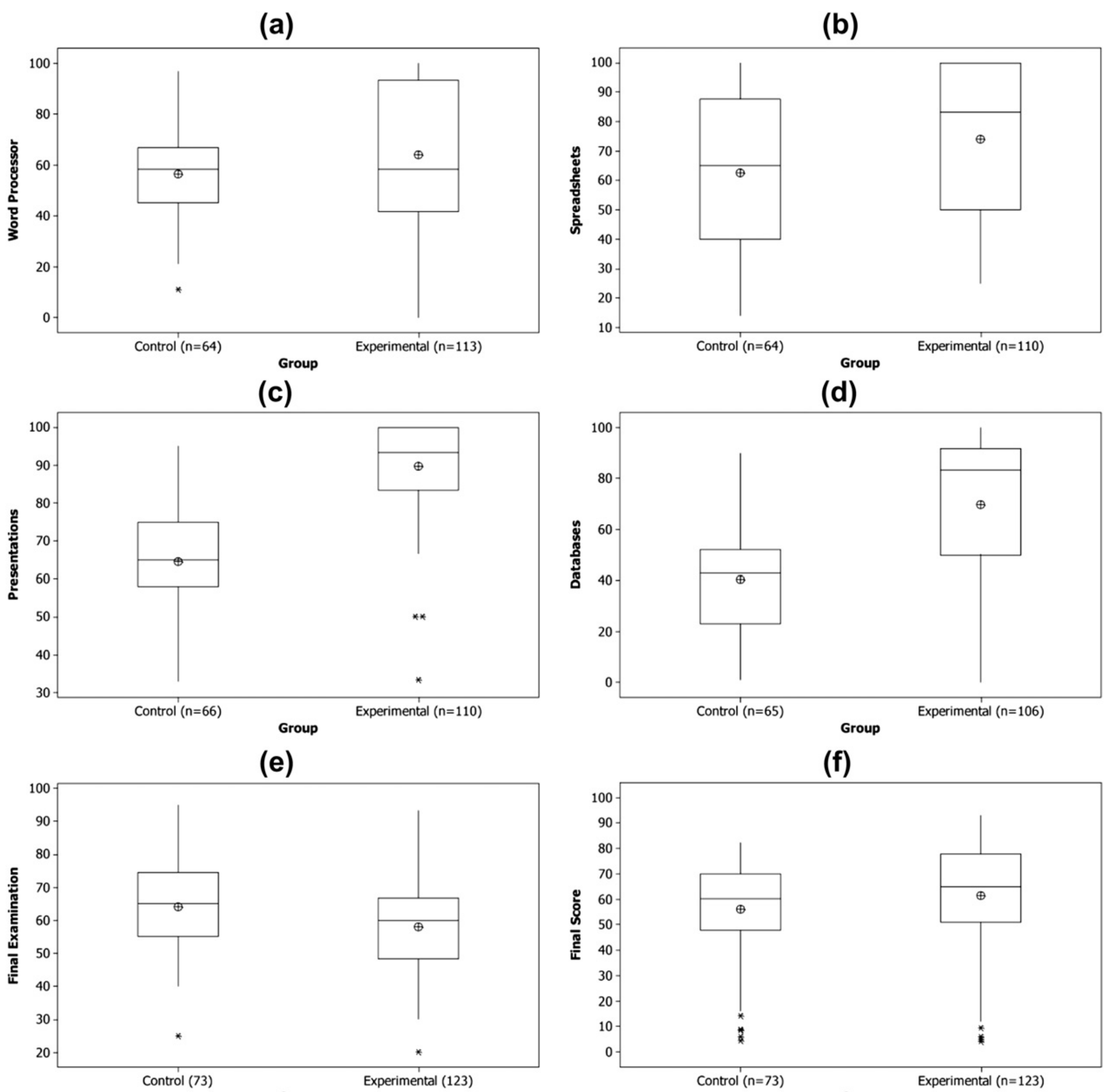

Fig. 6. Boxplots of the most significant scores.

Table 3
Final scores for the control, experimental non-gamified and experimental gamified groups. Significance was computed using one-way ANOVA tests.

Evaluation item	Group	*n*	Mean	Std error	Std dev	Significance
Initial activity	Control	73	77.29	2.41	20.63	$F = 5.85$
	Experimental non-gamified	96	86.25	3.12	30.62	$p = .003$
	Experimental gamified	27	96.30	3.70	19.25	
Word processor	Control	64	56.33	2.34	18.73	$F = 2.53$
	Experimental non-gamified	88	61.70	3.06	28.68	$p = .083$
	Experimental gamified	26	69.36	5.41	27.60	
Spreadsheet	Control	64	62.70	3.21	25.67	$F = 4.46$
	Experimental non-gamified	83	72.25	2.90	26.37	$p = .013$
	Experimental gamified	27	79.14	5.06	26.29	
Presentations	Control	66	64.59	1.52	12.38	$F = 93.13$
	Experimental non-gamified	84	89.11	1.40	12.58	$p = .000$
	Experimental gamified	26	92.31	1.67	8.53	
Databases	Control	65	40.25	2.84	22.86	$F = 28.17$
	Experimental non-gamified	80	68.77	2.91	26.05	$p = .000$
	Experimental gamified	26	72.37	5.21	26.55	
Final Examination	Control	68	64.12	1.66	13.67	$F = 3.99$
	Experimental non-gamified	81	57.67	1.60	14.39	$p = .020$
	Experimental gamified	25	59.27	2.77	13.84	
Participation	Control	73	86.53	2.42	20.67	$F = 82.14$
	Experimental non-gamified	96	40.52	2.51	24.64	$p = .000$
	Experimental gamified	27	75.19	5.43	28.20	
Final	Control	73	56.27	2.17	18.58	$F = 4.85$
	Experimental non-gamified	96	58.99	2.39	23.43	$p = .009$
	Experimental gamified	27	70.71	2.99	15.52	

a consequence of technological mediation. Our point is that such questions have a very strong philosophical underpinning and that further research and enquiry shall be performed before drawing unsustained conclusions. Particularly, studying approaches that circumvent enframing by carefully addressing social interaction seems promising. Furthermore, a closer examination of data when considering three groups (experimental gamified, experimental non-gamified and control) reveals that the real difference is between the non-gamified experimental ($M = 40.52$, SD $= 24.64$) and the control group ($M = 86.53$, SD $= 20.67$) and it is very substantial. The experimental gamified group also performs lower ($M = 75.19$, SD $= 28.20$) than the control group but there is no statistical significance. To be honest we have to say that we do not find any explanation for such an important difference. Courseware and methodology were exactly the same for experimental and control groups. The only difference was in the participating teachers as the number of students and groups required the participation of different teachers. Regular meetings were kept to ensure consistency between groups. So in our opinion we can only infer that either the teachers of the control group managed to keep their students participant or the students of the experimental group were really under-participative.

7.2. Attitudinal survey

The students of the experimental group were also asked to answer a questionnaire of 10 items designed to evaluate their attitude towards the learning tool and their satisfaction level. The instrument used was a questionnaire based on a five-point Likert scale with all the sentences scored in a positive scale. Similar instruments have been used by other researchers (Garrido, Grediaga, & Ledesma, 2008). The survey was answered anonymously. 45 students claimed to have followed the gamified experience and provided feedback. Questions and results are summarized in Table 4. The average for these questions is 3.64 on the five-point scale, indicating that the students' attitude to this experience was positive. The highest rated statements are items 6 and 7 suggesting that the activities were successfully designed according to students' perception. The ratings of items 2, 9 and 10 are especially significant because they provide a general positive estimation of

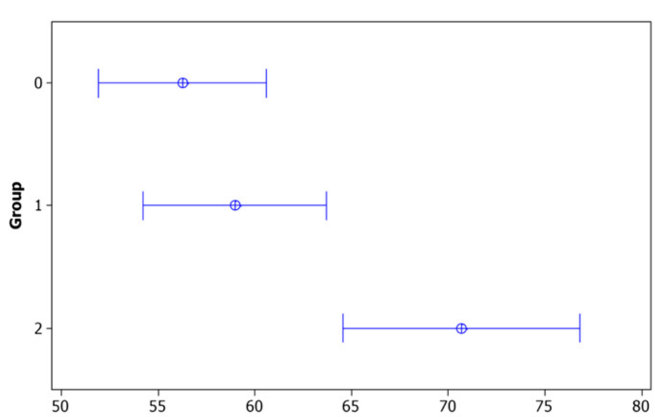

Fig. 7. Interval plot of the final score (95% CI for the mean). 0–Control group, 1–Experimental non-gamified group, 2–Experimental gamified group.

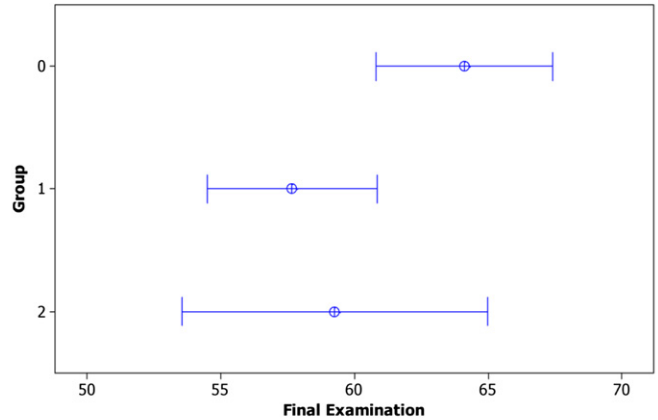

Fig. 8. Interval plot of final examination score (95% CI for the mean). 0–Control group, 1–Experimental non-gamified group, 2–Experimental gamified group.

students' motivation and students' attitude towards learning with this tool, not only during the learning experience but also in the future. In contrast, the lowest rated statement is item 4 which suggest that additional work to improve the usability of tool should be undertaken. Authors can only conjecture to what extent the integration of the tool in the BlackBoard system has an important role in this rating. Low rate on statement 8 indicates a low level of involvement. Regarding this, students were also asked to provide a percentage (0–100) estimating to what level they have completed the gamified activities. Results return a mean of 55.56 (SD = 21.56). We can contrast this with real data as the tool records every challenge and achievement completed by students. If we consider all the students who completed at least one gamified activity ($N = 58$) the mean is 22.65 (SD = 26.74) and considering only the students ($N = 27$) who completed 8 or more gamified activities (18.6%) the mean is 40.91 (SD = 29.59). So in our opinion students' estimation about their own work is (very) optimistic and participation rates are really low. We think that both researchers and teachers shall try to find ways to design new experiments and learning actions in which participation and its promotion play a central role since this is critical to evaluate learning activities and also to foster meaningful and efficient learning.

Answers variability in the attitudinal survey is low since overall SD is 0.96, which represents less than 1/4 of the mean. So it can be said that the answers are homogeneous. Item correlations are examined to determine the relevance of each item in relation to the other items and the entire survey. All items returned correlation coefficients larger than 0.4 suggesting coherence in responses. A factor analysis returns a cumulative explanation percentage of variance of 68.5 suggesting that the instrument also presents factorial validity. However, we have to be careful with this values concerning validity since the sample size (45) is considerably lower than the recommendations of standard benchmarks. To complete the analysis, Cronbach's alpha score is computed to measure the internal consistency of the survey. The overall Cronbach's alpha is 0.8629, which is higher than a commonly used benchmark value of 0.7. This suggests that the items measure the same construct.

57 students acknowledged to have not used the gamified version and were asked about the reason/s that prevented them from taken part in the gamified experience. Results are summarized in Table 5. Time availability is the most frequent reason argued by students. Technical problems are the second most important reason. The reason argued less frequently is the difficulty to use or understand the system, in marked contrast to the attitudinal survey in which tool ease-of-use is the lowest rated item. Under 'other reasons', students point out additional problems. Some examples are: "Too many students", "I have to visit too many web pages and applications in the university and I did not want a new one" and "I do not like competition between students and that everyone can see it."

Another informal questionnaire was included in the e-learning platform asking students whether they found it more motivating to complete gamified activities in contrast with the traditional version, and about which specific elements of the plugin have the biggest

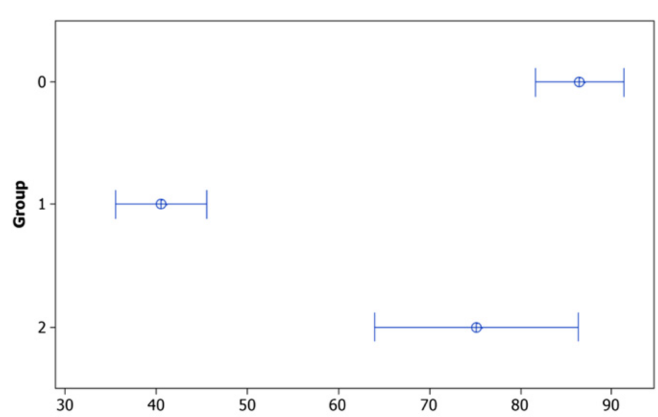

Fig. 9. Interval plot of the participation score (95% CI for the mean). 0–Control group, 1–Experimental non-gamified group, 2–Experimental gamified group.

Table 4
Questions and results of the attitudinal survey. Answers were provided in a five-point Likert scale (1–Strongly disagree, 2–Disagree, 3–Undecided, 4–Agree, 5–Strongly agree).

Item	*N*	Mean	Std error	Std dev
#1 Content was presented effectively	45	3.64	0.13	0.89
#2 I learned about the course topic	45	3.76	0.13	0.86
#3 I enjoyed the experience	45	3.49	0.15	0.99
#4 Using the tool was easy for me	45	3.24	0.18	1.15
#5 The proposed practical activities were useful	45	3.56	0.15	0.99
#6 There was a sufficient number of exercises	45	3.91	0.13	0.90
#7 There was sufficient time to complete the exercises	45	3.98	0.15	0.99
#8 My level of involvement was high	43	3.40	0.13	0.85
#9 I would like to learn more about the course topic	44	3.63	0.15	0.99
#10 This was a worthwhile learning experience	45	3.76	0.15	0.98
Average	–	3.63	–	–

motivational impact. 91 students provided feedback using this instrument. Concerning motivation students were asked if they found the gamified activities more motivating, if they found the traditional activities more motivating or if they found the gamified activities neither more nor less motivating that the traditional ones. 29 students (31.87%) found the gamified activities more motivating, 56 students (61.54%) found the traditional activities more motivating and 6 students (6.59%) felt no differences in their motivation. We can consider these figures to be consistent with the previous ones since the number of students that found it motivating is similar to the number of students (27) that completed a reasonable number of gamified activities. Thus, students that followed the gamified course seem to be motivated but further questions remain unanswered about students that did not start or quitted. The reward-based system programmed on the e-learning plugin is designed to improve extrinsic motivation. Although it can be a powerful force to drive intrinsic motivation, several problems have been reported concerning extrinsic motivation. First, participants can feel manipulated. Second, little or no transfer can occur if behavior is only driven by rewards. And finally, if the reward vanishes so does the behavior. In this way, the learner may become too dependent on the reward or she may be not interested at all on it (Lepper, 1988). We conjecture that students who did not follow the gamified approach or quitted were partly not attracted by the reward mechanics implemented. Nonetheless, we think that this was not the only reason but rather that the other reasons argued by students and the lack of immediate feedback also contributed to the low motivation level observed.

7.3. Qualitative analysis

Finally students had different opportunities to provide additional feedback about their perceptions and attitude towards the system and the learning experience. In the anonymous attitudinal survey there was an open question in which students were asked to provide any comment or suggestion. 17 students provided feedback using this mechanism. The e-learning platform also provided a source of permanent communication between teachers, researchers and students. Forums were used as a source of feedback and a specific feedback form was also available in the e-learning platform. Teachers and researchers analyzed all elements to create also a qualitative appraisal of students' perceptions and motivations.

In general we get numerous positive responses. The following comment can be taken as an example. It stresses the importance of the leaderboard and also the fact that, as for all activities, completing them was a way to contribute to the participation score: "I have completed the gamified activities because by means of the leaderboard, global statistics,…; I can know what is the amount of work that I have done with respect to other students. The fact that my activities were also contributing to the participation score also influenced me." The following reflection is representative of the possibility to choose between both versions of the activities. The student asserted that he had completed the gamified activities "because the leaderboard was motivating for me, and also as I was going to complete the activities in any case, I preferred the gamified version." Another student interestingly commented: "I preferred to make the gamified ones. Decision that I have taken for the simple reason that by completing them, but previously done them in the traditional way as the instructions are better, and then submitted to the new virtual platform to win new points as it is fun and motivating in many ways, be it for the graphics, the trophies … and it is even more colorful and encouraging." Here the student is presenting his experience as a combination of both approaches (traditional and gamified). He prefers the traditional approach to go through the activities, but finally he completes them in the gamified version because he finds it motivating, encouraging and even 'colorful'. These as well as similar comments stress the importance that competition has for some students as well as the chance to have the same contents in different formats which can be combined to create meaningful and motivating learning experiences.

Contrasting with positive comments, we also found opposing opinions. We found especially interesting those that reflect about the dislike and uneasiness created by the leaderboard and the feeling of competition among students. For instance, this student states "I prefer traditional activities because I don't think that leaderboards are a good representation of who gets more knowledge about the course" or another student who states "I think that it would be more interesting to improve the traditional version, instead of making competitions."

Table 5
Reasons for not using the gamified version ($N = 57$). Students could point more than one reason.

Answer	Frequency
I do not know about them	9
I am not interested in them	6
I do not have time to complete the activities	34
I find technical problems	13
The system is difficult to use/understand	3
Other reasons	17

We mentioned above that similar statements were argued among the reasons for not using the gamified system. All other negative perceptions can be categorized in three groups: (1) preference for traditional-like activities because "they are easier" or "I feel more comfortable with them", (2) "I did not have time, and I didn't know what difficulties I was going to find", and (3) "By having the option of the normal system, the game I thought it would take longer."

8. Conclusions and future work

Gamification in e-learning platforms seems to have potential to increase student motivation, but it's not trivial to achieve that effect, and a big effort is required in the design and implementation of the experience for it to be fully motivating for participants.

On the one side, experiment qualitative analysis suggests that gamification can have a great emotional and social impact on students, as reward systems and competitive social mechanisms seem to be motivating for them. Reward systems suppose an innovative, fun and encouraging way to represent progress within an online educative experience. Leaderboards also serve as a source of motivation because students see their work publicly and instantly recognized, and because they can compare their progress with other classmates. These good results don't happen for everyone though. For many, the system was not motivating enough to participate along the course. In some cases the system was even discouraging, as some students don't find it fun to compete with their classmates for a rank in the leaderboard. Our work is influenced by studies on the profiles of players who foster competition. For instance Heeter, Lee, Medler, and Magerko (2011) identify four types of players based on performance and mastery levels of achievement goals, namely: performance-only players, mastery-only players, non-achievers and super-achievers. Arguably, other styles of players, like socializers or explorers, have to be considered. Our future work will try to address these issues, reducing the overall importance of competition and rewards, and introducing cooperative and social mechanisms which are currently being used in the so called "social games" (Hicks, 2010). We will also try to find new ways of gamification that are more meaningful to the students, not limiting the system to extrinsic rewards like achievements and badges, as suggested by Deterding in his presentation "Meaningful Play: Getting gamification right",[5] and by Nicholson in his User-Centered Theoretical Framework for Meaningful Gamification (Nicholson, 2012).

On the other side, quantitative analysis suggests that cognitive impact of gamification over students is not very significant. Students who followed traditional exercises performed similarly in overall score than those who followed gamified exercises. From our point of view, cognitive characteristics of videogames that create the so called "cycles of expertise" (Gee, 2003) that further derive into "flow experiences" (Csikszentmihalyi, 2008) are in the very nature of the medium, and cannot be exported to traditional educative content by any way without entering in the field of edutainment or serious games. Although gamification impact on the cognitive aspects of educative content is limited, we still think that changing content design and structure to make it more fun can have great motivational impact. One suggestion is to design educative exercises embracing from the very beginning the concept of gameful design (Deterding, Dixon, Khaled, & Nacke, 2011) to make them more interesting for students. Additionally we shall consider a more systematic approach for the design and evaluation of gamified learning. We shall take previous work on evaluation frameworks in game-based learning, e.g. (de Freitas & Oliver, 2006), as a starting point. This will enable us to extract more solid conclusions about the reality of gamification in education.

Apart from exposed lines, students reported other design and technical issues that should be addressed in future works. Some of them complained about the Blackboard plugin because it was hard to use or didn't work well. Although students were introduced to the plug-in by the teacher and by a textual tutorial, it seems that those introductions were not good enough for all students to be able to use the plug-in proficiently. On future versions, we might consider including an interactive introduction which not only explains, but also guides students step by step on plug-in features usage. Some important technical problems may be related to the Blackboard platform, as it introduces network overload that slowed down screenshot uploading, making it tiring and time consuming. The proprietary code of Blackboard platform made it impossible for us to fix this, and we didn't manage to find a workaround solution. Other potential issues may have risen with an appropriate usability and software testing process. An important conclusion that students' reports suggest is that a good testing process is essential when developing a gamification system; otherwise its motivational effects can be dramatically diminished by unaddressed usability and technical issues.

Another important problem was task evaluation. Many students didn't complete gamified exercises because they thought that it was a waste of time to capture and upload screenshots of their work. This may also be related to the technical issues that slowed down screenshot uploading, but it was not the only problem. Participants also reported that they could upload empty screenshots to obtain achievements in an attempt to cheat. Finally, teachers had to do additional efforts to correct all the screenshots in order to validate student's achievements. All these facts indicate that gamification has some limitations when tasks cannot be automatically evaluated by the e-learning platform as a conflict arises between immediate feedback, fair rewards and teacher effort. We think that immediate feedback will increase students' motivation yielding better results. This is a critical aspect of videogames that makes them compelling and engaging so gamified initiatives must address it (Kapp, 2012). As future work we have to design new methods to automate the work that teachers must do, and also develop the tools to enable them to create and modify the gamified learning experiences easily, making the underlying technological infrastructure transparent. Unsupervised scoring systems (Goldberg & Song, 2004) may also be an interesting solution to this problem, and response-driven feedback approaches (Fernández-Alemán, Palmer-Brown, & Jayne, 2011) can help teachers to produce meaningful and rapid feedback.

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