Engaging Engineering Students with Gamification

An empirical study

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Abstract—Well-designed games are good motivators by nature, as they imbue players with clear goals and a sense of reward and fulfillment, thus encouraging them to persist and endure in their quests. Recently, this motivational power has started to be applied to non-game contexts, a practice known as Gamification. This adds gaming elements to non-game processes, motivating users to adopt new behaviors, such as improving their physical condition, working more, or learning something new. This paper describes an experiment in which game-like elements were used to improve the delivery of a Master's level College course, including scoring, levels, leaderboards, challenges and badges. To assess how gamification impacted the learning experience, we compare the gamified course to its non-gamified version from the previous year, using different performance measures. We also assessed student satisfaction as compared to other regular courses in the same academic context. Results were very encouraging, showing significant increases ranging from lecture attendance to online participation, proactive behaviors and perusing the course reference materials. Moreover, students considered the gamified instance to be more motivating, interesting and easier to learn as compared to other courses. We finalize by discussing the implications of these results on the design of future gamified learning experiences.

Keywords—Gamification; Education; Student participation; Classroom learning; Evaluation

I. INTRODUCTION

Education is a great concern of modern society and many efforts have been applied to make it both more effective and available to everyone. Traditional teaching techniques rely on blackboards, oral lectures, books and written exercises as the main vehicles to transmit knowledge. However, technological process brought new possibilities to teach and educate, such as using video games [1, 2], which spiced up curiosity and fired discussions amongst many educators and researchers [3, 4, 5]. Research shows that video games have a great potential to improve learning experience and learning outcomes. In independent experiments, middle-school, high-school and college students were subject to learning with video games, reporting significant improvements in subject understanding, diligence and motivation [6, 7, 8, 9, 10, 11]. Good games are natural learning machines, as found by Gee [12]. Unlike traditional educational materials, games can deliver information on demand and within context. Successful games are designed to be challenging enough to prevent players from

becoming either bored of frustrated, thus allowing them to experience flow [13, 14].

The motivational power of games is being explored in many non-game contexts, through a novel technique called gamification. It adds game elements to non-game processes, rather than using full-fledged games [15, 16]. Gamification has been used mostly to keep users engaged with products and motivated to perform certain behaviors [17, 18], which has made it particularly useful for marketing [19, 20]. However, it has also found applications in many other domains, such as helping people become healthier (e.g. Nike+[1], ZombiesRun[2]), more productive [21] or more eco-friendly [22].

Many gamified systems focus on keeping users engaged while learning new techniques and tools. Microsoft Ribbon Hero[3], for example, encourages users to explore Microsoft Office tools, and Adobe LevelUp[4] does the same for Photoshop. Jigsaw [23] helps users learn Photoshop, through an embedded jigsaw puzzle that challenges players to match a target image. Although an empirical evaluation of this technique has yet to be performed, users reported being able to explore the tool and discover new techniques. GamiCAD [24] is a gamified tutorial system on how to perform line and trimming operations in AutoCAD. By completing tasks, users help NASA build a spacecraft to participate in an Apollo mission. Tasks are designed to be challenging and users are encouraged to repeat those until they achieve the required score. Results show that users completed tasks faster in GamiCAD and found the experience to be both more engaging and enjoyable than using a non-gamified version.

In his book, Lee Sheldon [25] describes how a conventional learning experience can be designed as a game without resorting to technology, to engage students and make classes more fun and exciting. Students start with an F and go all the way up to an A+, by completing quests and challenges, and gaining experience points. However, little statistical data are provided to support the claimed potential benefits of this approach. Khan Academy[5] is a free online service that allows

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[1] http://nikeplus.nike.com/

[2] https://www.zombiesrungame.com/

[3] http://www.ribbonhero.com/

[4] http://success.adobe.com/microsites/levelup/index.html

[5] http://www.khanacademy.org

users to learn about several subjects, like algebra, economics or history, by watching videos and then performing exercises. Their progress is rewarded with energy points and badges. In a similar fashion, Codeacademy[6] teaches online students to code in several programming languages, also using points and badges to track their progress. Even though systems like these have been used in flipped classrooms [26], their applicability to conventional classroom setups is limited. We still lack empirical data to support any correlation between gamified setups and student engagement. With a wide range of course types, student backgrounds, learning preferences and socio-economic environments, more systematic studies of the influence of different gamification techniques are required to assess how effective they can be.

In this article we evaluate how gamification affects students of a college course named Multimedia Content Production (MCP). Firstly, we describe a long-term study carried out over two consecutive academic years. In the first year, a non-gamified version of the course was used, similarly to previous years. In the second year, we deployed a gamified edition, containing game elements such as experience points, levels, leaderboards, challenges and badges. Secondly, we compare different aspects of the students' learning experience, including attendance, participation and usage of reference materials. Then we carefully analyze the resulting empirical data, which show significant gains in engagement, dedication and satisfaction. We finalize by discussing the lessons learned from this experiment and by deriving relevant design implications to future gamified learning experiences.

II. THE MCP COURSE

MCP is an annual semester-long MSc course in Information Systems and Computer Engineering at Instituto Superior Técnico. This engineering school has two campi, Alameda and Taguspark, where the course runs simultaneously. In the first year, course evaluation consisted of five theoretical quizzes (25% of total grade, the best out of six), a multimedia presentation (20%), lab classes (15%), a final exam (35%, the best out of two attempts), online participation (5%, for online forum discussions) and class attendance (5% extra grade). The final grade was represented with a value between 0 and 20. In the second year, instead of grade points, students participated in a game-like experience and were awarded experience points by meeting the traditional evaluation criteria. It consisted of quizzes (20%), a multimedia presentation (20%), lab classes (15%), a final exam (35%) and a set of collectible achievements (10% plus a 5% extra). Compared to the previous edition of the course, the evaluation method was thus similar, with achievements replacing the online participation and attendance bonuses, as well as 5% of the grade originally awarded by the quizzes.

In both years, the faculty staff was composed by the same four teachers, two for each campus. The courses were completely synchronized, using a single shared online Moodle platform[7]. In the first year, 42 students attended the course (12 in Alameda and 30 in Taguspark), a number that decreased to

6 http://www.codecademy.com/
7 http://www.moodle.org

35 in the second year (12 in Alameda and 23 in Taguspark). Students had similar backgrounds in both years. A large majority had finished their undergraduate computer science degree on the previous year, and three foreign exchange students (Erasmus). In the first year, the syllabus included 19 regular lectures, 13 lab classes and three invited lectures, whilst in the second one, the numbers were similar: 18 lectures, 12 lab classes and four invited lectures. The theoretical lectures span multimedia concepts ranging from capture, to editing and production techniques, file formats and multimedia standards, as well as Copyright and Digital Rights Management. In laboratory classes, diverse concepts and tools were introduced to students on image, audio and video manipulation. The PCM Media Mixer prototype, a multimedia editor built on DirectShow, was also introduced, for which students had to develop manipulation and navigation plugins.

III. GAMIFYING THE COURSE

By analyzing student performance data from previous years, we found room to improve student engagement in the course, as shown by their low online participation on Moodle, low attendance rates and lack of interest in the reference material (low number of downloads). In order to make the course more engaging, fun and interesting, we gamified it by adding experience points (XP), levels, leaderboards, challenges and badges, which seem to be some of the most consensual game elements used in gamification [27, 28, 20, 29].

Similarly to Sheldon's approach [25], instead of beginning with the maximum grade and having to strive to maintain it, our students begin with the minimum. Thus, they are encouraged to learn from failure instead of feeling penalized. In place of the traditional grading system, students now have XP, which are awarded to every course activity they can undertake. XP provide direct feedback on how successful students are being and also serve as instant gratification, which was previously shown to be successful in motivating college students [30].

Students climb through levels as they progress at a rate of 900 XP per level or 900 XP to complete level 1, 1800 XP to finish level 2, 9000 XP to get to level 10 and 18000 XP to reach 20, the top level. Each level thus directly translates to an assigned grade on a 0-20 scale. To prevent rounding problems, we gave students a head start of 450 XP, awarded as a bonus for enrolling in the course. Furthermore, to introduce a distinctive flavor to levels, each corresponded to a unique title. For instance, level 1 was labeled "Starting to see the light", level 4 "Taking your first Steps", level 12 "Knowledge Pilgrim" and level 20 "Science God". Levels, together with points, transmit progress and positive feedback to students.

The leaderboard webpage (see Fig. 1) provides an entry point to the gamified experience. It is publically accessible through the Moodle forum and displays enrolled students by row, sorted in descending order by level and XP. Each row portrays the player's rank, photo and name, campus, XP, level and achievements awarded for completing course activities. As examples of such activities we have attending lectures, finding resources related to class subjects, finding bugs in class materials or completing challenges. Just by looking at the

Fig. 1. MCP course leaderboard

Fig. 2. Badges and Achievements

leaderboard, students can monitor their own progress but also see how others are doing. Furthermore, by clicking a student's row, the achievement history for that player is displayed (see Fig. 2). This makes progression transparent and allows students to learn by watching others. The leaderboard transmits progress but also provides players with means to compare themselves to others, which spurs competitiveness and may render the experience more engaging.

Challenges are the major behavior drivers in the experience. They consist of actions students must perform to be awarded with XP and collectible achievements, or badges. There were two main Challenge categories. Theoretical Challenges are activities presented to students throughout the semester, at the end of some lectures. These were organized as small creative tasks designed to explore multimedia types and materials taught in those lectures. Students could earn a "Rise to the Challenge" achievement by accomplishing these tasks. The other category consists of Lab challenges, which were assigned during the first month of classes. These were meant to be fun and expressive, by allowing students to produce creative content using multimedia tools introduced in lab classes to earn the "Proficient Tool User" badges. Throughout the rest of the semester, students could earn achievements by finding bugs in the PCM Media Mixer prototype ("Bug Squasher" badges). All challenges were normally assigned a one-week deadline.

Challenges were formally issued via posts to course fora by faculty. Achievements and graded activities were recorded based mostly on students' posts, except for attendance, lab grading, quizzes and exams, which were manually scored. Challenges and achievements serve the main purpose of structuring course activities into meaningful endeavors while

allowing students to choose what tasks and achievements to pursue. Achievements also provide important feedback to transmit how proficient students become on specific aspects of the course. They also grant students with bragging rights and explore their need to collect. Whilst some achievements are single-level, i.e., only require players to perform the task once, others are multi-level, which require multiple iterations with increasing difficulty. Multi-level achievements aim to make things more interesting for students, by portraying progress and allowing them to choose whether to level up or not.

To make the onboarding process easier, we conceived a few less difficult achievements to be awarded during first steps. This provided students with early feedback and motivation to keep going. Moreover, we assigned greater scores to the first levels of multi-level achievements, to encourage students to try different challenges. To further motivate students to embrace optional activities, we created achievements that awarded them extra XP (although the final grade tops at 18000 XP). We had a total of 900 bonus XP distributed by 39 optional achievements and 1800 mandatory XP shared throughout 22 achievements. The remaining mandatory 16200 XP were allocated to quizzes (3600 XP), lab evaluation (2700 XP), a thematic multimedia presentation (3600 XP) and a final exam (6300 XP, best out of two). We had five quizzes (scored best out of six) on every other week, each worth 600 XP (120 XP per question). There were four laboratorial evaluations worth 675 XP each, in which students had to develop algorithms to manipulate video data.

The whole scoring process was done manually. Data from lectures and lab classes were collected by faculty on excel sheets with macros, which then exported the information to text logs. Also, data logs from Moodle activity were daily downloaded by hand. Then, faculty ran a python script manually to process all log files and generate the leaderboard webpage. The script was run two to three times a day to track major updates with low perceived response time.

It is important to remark that some of the game elements including points and badges, work as extrinsic rewards, and that extrinsic motivation may crowd out the intrinsic [31, 32]. However, these elements try to align the goals of the course with those of the students (to learn and pass the course), which should motivate them through identification and integrated regulation. According to the self-determination theory [33], these are the most autonomous forms of extrinsic motivation and share some qualities with the intrinsic forms. Thus, we try to use gamification as a means to amplify the intrinsic value [34]. To attain this, we try to improve the feelings of competence, autonomy and relatedness in students, which satisfy three basic needs to intrinsic motivation [33]. The sense of competence is promoted through positive feedback and displaying progress via points, levels and badges. These are also important characteristics of playing and learning [35]. We provide learners' with a sense of autonomy by allowing them to choose which challenges to pursue and which achievements to level up. Finally, we boost their sense of relatedness by allowing them not only to cooperate and share opinions on Moodle but also to compete via the leaderboard.

IV. RESULTS

We collected data regarding many aspects of student performance and satisfaction, such as the number of course lecture slides downloads, the number of posts in forums, class attendance and grades. These elements have previously been used as informal measures of student engagement [36]. In this section we will compare these values between the two years and address the main changes between them. We will also present and discuss student feedback from the satisfaction surveys, issued at the end of the course. Since data do not appear to follow a normal distribution, all statistical differences between groups were checked using a non-parametric Mann-Whitney's U test.

A. Number of Downloads

Despite having fewer students, we had 789 (2765 vs. 1976) more course lecture slides downloaded in total. A Mann-Whitney's U test revealed significant differences between the two years ($U = 75$, $Z = -2,917$, $p < 0,003$), showing an increase in average downloads per lecture of 49.61 (153.61 vs. 104), which translates to a gain of 47.7% (see Fig. 3). Lecture material downloads per student also had a similar growth (see Fig. 4), with a total increase of 31.95 (79 vs. 47.05) downloads and a significant growth per lecture of 1.91 (4.39 vs. 2.48) (Mann-Whitney's U test, $U = 51$, $Z = -3.647$, $p < 0.001$).

When analyzing how course materials were downloaded throughout the semester, one thing caught our attention. By the middle of the semester, downloads dropped dramatically (see Fig. 5). This was already expected to happen during Easter
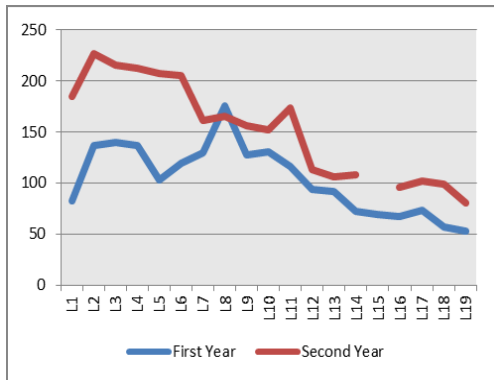
Fig. 5. Slide downloads over time during the second year
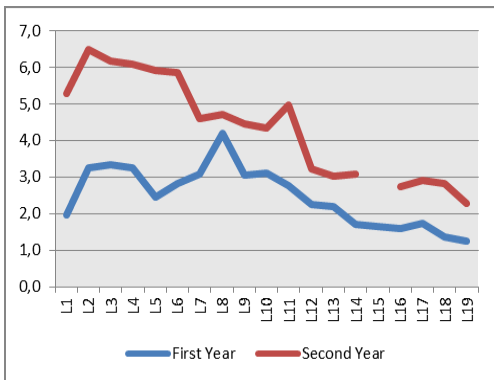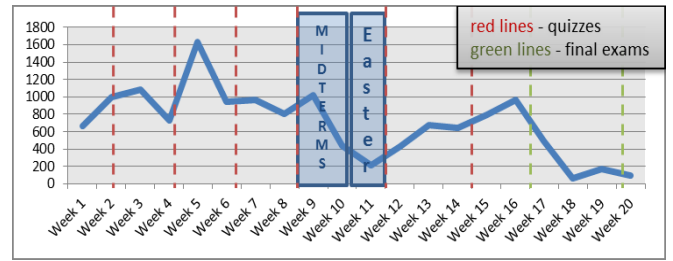
break (April 21th to 27th), but it started a couple of weeks earlier. It turns out that other courses had mid-term exams during that period, which diverted the students' attention. Interestingly enough, the number of downloads never went back to previous rates, which might be related to schedule constrains on students. We could also see that there was a slight rate increase during quiz weeks.

B. Number of Posts

Posts made by students increased drastically with the gamified experience (see Fig. 6), thus suggesting both higher participation and proactivity. There was a total growth of 845% (104 vs. 11) in initiated threads (first posts) and an average growth per week of 751% (5.2 vs. 0.61), differences which are statistically significant (Mann-Whitney's U test, $U = 36.5$, $Z = -4.314$, $p < 0.00001$). Reply posts also grew, with total gains of 511% (801 vs. 131) and gains per week of 450% (40.05 vs. 7.28) (Mann-Whitney's U test, $U = 66$, $Z = -3.337$, $p < 0.001$). Replies and first posts combined together increased by 537% (905 vs. 142) totally and 474% (45.25 vs. 7.89) in a weekly basis (Mann-Whitney's U test, $U = 52.5$, $Z = -3.731$, $p < 0.0001$).

Results also lead us to believe that students were not the only ones getting excited by the MCP game. It turns out that

Fig. 3. Number of downloads of lecture slides

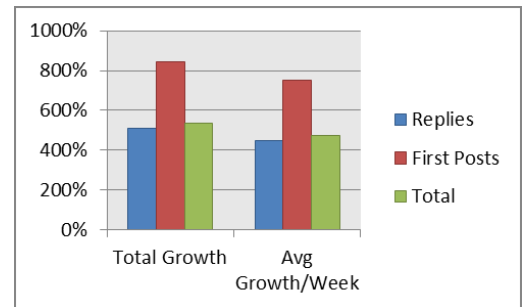Fig. 4. Average lecture slides downloaded per student

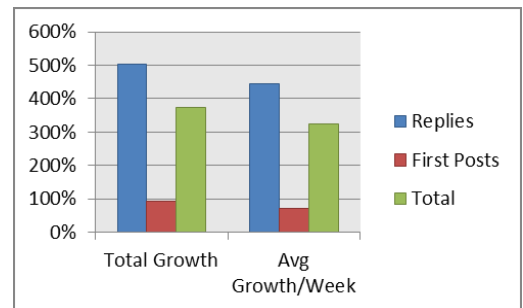Fig. 6. Growth in number of posts from students

Fig. 7. Growth in posts from faculty

faculty also made more posts, increasing 373% (534 vs. 113) with a weekly growth of 325% (26.7 vs. 6.28), and these differences were statistically significant (Mann-Whitney's U test, U = 69, Z = -3.251, p < 0.001) (see Fig. 7). However, this significance only extends to the number of replies, where total gains reached 504% (465 vs. 77) and with weekly gains of 444% (23.25 vs. 4.28). As for first posts, there were slight increases whose significance could not be demonstrated. These changes in the faculty activity were expected, due to increased student demands for feedback.

Student posts were expected to increase, given that evaluation changed to include achievements. Despite being worth 10% of the grade (+5% bonus), this new component was responsible for 363 posts, which is more than twice the total posts in the previous year, thus suggesting it can indeed engage students into participating in forums. The evaluation components unchanged between the two years were responsible for 542 student posts, which grew by 281% compared to the first year's 142. This suggests that the gamified course engaged students to participate significantly more, even without considering the new evaluation component.

Post activity to forums throughout the semester, both by students and faculty, increased by 464% to 1439 (either initial or reply posts), as compared to the previous year's 255. Of these, 402 were related to Theoretical Challenges and 279 discussed Lab Challenges (see Fig. 8). This suggests that the
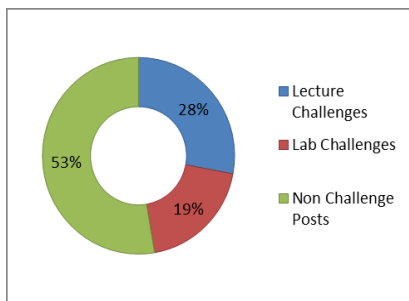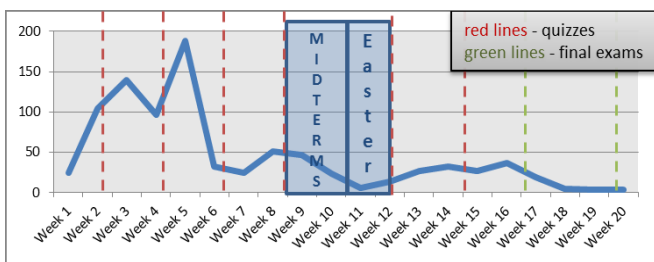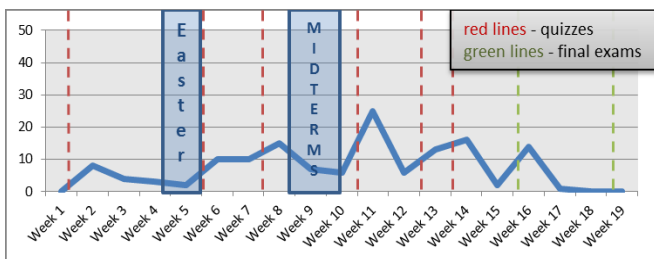
tandem challenge/reward is a powerful driver of student behavior, accounting for 47% of all posts.

Analyzing post activity over time, we saw that during the three-week period leading to Easter break, posts follow a similar pattern to downloads (see Fig. 9). There was a noticeable decrease that might be related to mid-term exams from other courses, a phenomenon also evident in the previous year (see Fig. 10). Furthermore, from the Easter break on, posts activity never quite recovered pre-break rates. This might have been caused by lack of time due to other courses, which usually hand out their project assignments at this time. Further study is necessary to understand whether this is the sole reason.

A close comparison of post evolution between the two years shows that the second year indeed saw more posts, but the majority occurred in the first two months of classes (see Fig. 11). This might be related to the challenges posted during this period. The three Lab Challenges were posted during the first month of classes and added up to 279 posts, 19% of the total amount for the semester. Moreover, these challenges had the three longest discussion threads, with 94, 93 and 92 messages respectively. Theoretical Challenges also seem to have a very significant impact, with six out of nine posted during the first two months, accounting for almost 84% (336) of the posts regarding Theoretical Challenges. For five of the challenges, 43% of the students (15) gave multiple answer posts (average of 1.6 additional posts), even though only one would be graded, suggesting that they enjoyed the freedom of creativity and were having fun. All of this goes to show that challenges indeed led to more student participation and engagement but also that the fact that they were not equally distributed over time may have rendered the second half of the course less appealing.

C. Attendance and Grades

The gamified approach also seems to have had a positive impact on lecture attendance. Average attendance by lecture for both the first and second academic years were 81% and 92%, which represents a significant difference of 11% (Mann-Whitney's U test, U = 51, Z = -3.654, p < 0,001). However, we were not able to verify the same for invited lectures, whose average attendance decreased by 14% (67% vs. 53%), even though this result was not statistically significant. This lower value might be related to students deeming invited lectures to be less worthy of their time, either because they are not relevant to exams or because they would occur on a single campus, which posed mobility issues. As for student grades, there were no statistically significant changes in the grade

Fig. 8. Post distribution in the second year

Fig. 9. Total posts over time in the second year

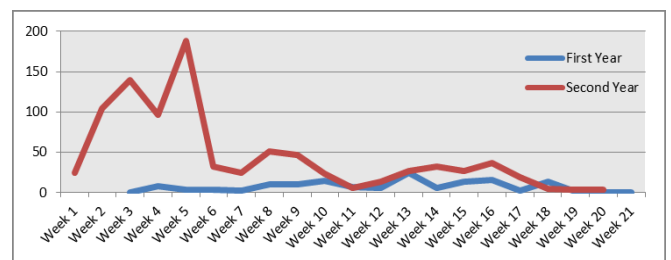Fig. 10. Posts over time in the first year

Fig. 11. Comparison of the number of posts made by students between the two years

average. Additional studies are needed to identify possible correlations between gamification and student grades.

D. Student Feedback

By the end of the semester, we carried out a questionnaire to gather quantitative and qualitative feedback about the gamified experience. Students first had to rate a set of phrases using a five-point Likert scale. Taking the mode of the answer into account, students considered that the gamification experiment applied to the MCP performed very well (4) [1 – terrible; 5 – excellent]. When comparing to other courses, they considered the MCP course to be much more motivating (5) and interesting (4) [1-much less; 5 - much more]. They also considered that the course required more work (4) but was neither more difficult (3) nor harder to learn from (3) [1-much less; 5 - much more]. They considered the study to have the same quality (3) of other courses, but with a greater continuity (4) [1 - far less; 5 - far more]. Students mildly felt that they were playing a game instead of just attending a regular course (3) [1 - not at all; 5 - a lot] and they had not a clear opinion on whether achievements should account for more of the course grade or not (3) [1-definitely not; 5 - definitely yes]. Furthermore, students considered that they performed non-mandatory tasks more for the sake of the game than for their grade (4) [1-grade only; 5-game only], which suggests a deeper engagement. Also, students deemed achievements that required extra work, such as "Class Annotator" and Challenges, to have contributed to their learning (4) [1-not at all; 5 - definitely] and agreed that gamification should be extended to other courses (5) [1-definitely not; 5 - definitely yes]. They also suggested that the game illusion could be improved by adding usable items and avatars, by establishing an achievement tree, and by promoting direct competition among learners. Last, group achievements could also be added, so that the whole class could work together, and oral participation in class should also be rewarded.

We also asked students to rate achievements according to their effectiveness. Highest rated were "Proficient Tool User", which allowed them to understand topics taught in the labs by producing creative content with multimedia tools; "Rise to the Challenge", where they had to complete theoretical challenges, which helped them understand subjects from lectures; and "Amphitheatre Lover", that encouraged them to attend lectures. They rated as least effective "Post Master", that rewarded then for the number of posts, because "quantity does not equal quality", and students noticed that a string of weak posts would get more XP than fewer posts of more thought out messages; "Bug Squasher", since fixing bugs in PCM Media Mixer required considerable coding, not commensurate with the reward; and the "Attentive Student", because finding errors on slides was a tedious task and they did not feel to be learning, even if they had to carefully read class materials in order to find errors. There were, however, a few achievements about which students had mixed feelings, such as "Bookworm", that encouraged them to do something that they already had to do, like reading the slides (the number of downloads increased 39.9%, nonetheless); "Class Annotator", that rewarded them for finding resources related to lectures, because some of the posted links were deemed irrelevant and many students did not

like homework, although some said that it helped them to think out-of-the-box; and "Challenger of the Unknown", where they had to submit contributions to the online quests forum, as while some said it provided them with a game-like feeling, others found it uninteresting and too similar to "Class Annotator". The original idea of both was very different, so this shows they may have been improperly described to the students.

V. DISCUSSION

The results from the experiment are very encouraging. They show notable gains in terms of attendance, participation and material downloads, which suggests improved engagement and diligence. In this section we discuss how many aspects of the students' experience were affected by the gamified installment of the MCP course, as well as the design implications for future gamified learning experiences.

A. Engagement, Satisfaction and Performance

The average attendance for regular lectures significantly increased 11% from the first to the second year, which suggests that students had greater interest in attending classes. The number of posts made by students presented the largest growth with 511% more replies in the second year and 845% more initiated threads. This suggests not only more participation but also a massive increase in proactivity, which reflects a greater willingness to engage in discussions. It is important to note that the amount of posts in the second year is still 281% larger than the first year if not taking into account the new evaluation component. Furthermore, 47% of the total posts in the second year related to challenges students had to complete, which would award them with XP and badges. This suggests that challenges are indeed both good engagers and behavior drivers, as supported by recent studies (Chen, 2012), but also that the desire to collect may also be a powerful motivator.

The significant increases in the number of downloads, posts and attendance indicate that students were more engaged with this new gamified learning experience than they were with the previous non-gamified one. Students were generally satisfied and found the MCP course to be more motivating and interesting than other courses, even though it required more work. This is an interesting finding. Indeed, students often complain about heavy workloads. However, using gamification, they did not mind spending more time working for the course and were more satisfied. While this suggests that students were motivated to work, it is not clear whether this motivation was extrinsic or intrinsic. This is a topic for future research. Even though we have no evidence that their marks were significantly affected by the game-like experience, we know that they spent more time working and have enjoyed MCP more than other courses. Notwithstanding, it would be of interest to identify a correlation between student grades and gamified learning.

B. Design Implications

We learned that challenges have to be carefully crafted in order to add meaning and interest to a gamified learning experience. Students preferred challenges like "Proficient Tool User", "Rise to the Challenge" and "Amphitheatre Lover",

whose main goal was to encourage them to attend lectures, explore topics taught on lectures and, above all, to create and be expressive, which is something that is not usually promoted in traditional engineering courses. These goals were not only in line with their personal objective of passing the course, but they were also creative and fun, which is why students made multiple replies to some challenges when only one would count for grading. This might have rendered challenges more meaningful, which as seen in the literature, is of major importance [33]. It also explains why other challenges, such as the "attentive student" (find typos in class material) were less popular, as they were perceived as meaningless.

While points, levels, multi-level achievements seem to have worked well to transmit competence and mastery to students, it was much harder to convey autonomy due to the course evaluation constraints. However, students had the freedom to be creative in challenges and to choose tasks and achievements to pursue, and which were worth leveling up or not. As suggested by students, this could be further improved by adding achievement trees, in which some achievements would only be unlocked once the preceding ones were accomplished.

We also found that the balance between how hard and how gratifying a challenge is, is also important to keep students engaged, which can be related to the flow theory [13, 14]. This explains why the "Bug Squasher" achievement was the least popular. Fixing source code bugs and recompiling the course's prototype for only 40 extra XP was not worth the effort. Furthermore, we found that challenges should be spread throughout the term to avoid periods where appealing goals may lack, or else students will become bored and demotivated.

Students suggested that the gaming experience could be improved by adding items with interesting effects, achievement trees and by representing each player with a customizable Avatar, which would allow students to develop online identity, reputation [28] and become more committed. It was also suggested that there should be more direct competition among students, such as rewarding those that accomplish an achievement before anyone else. However, students also saw room for cooperation, and suggested adding group achievements, like rewarding everybody if every student reached at least 80% of the maximum grade. This could yield interesting effects in the whole class dynamics.

We acknowledge that there are additional improvements that could be made to this gamified setup to further engage students, such as rewarding oral participation and giving more experience to higher achievement levels, as the current setup might make top levels less appealing. The interface could also issue notifications to transmit progress, and the leaderboard could allow students to perform direct comparisons with others. Student posts' quality should also be accounted for grading, to avoid pointless posts and promote fairness.

C. Study Limitations

Our study has three major limitations. Firstly, there is the controversial problem of over-justification with extrinsic rewards. Even though students are rewarded with points and badges, these serve the main purpose of transmit progress and positive feedback, and we avoid giving them too much emphasis. We try to counter this issue by providing meaningful challenges. Other game element setups could be experimented to assess this effect.

The second limitation concerns the competitive nature of our gamified experience. This was early decided due to the nature of our college and student population, which tends to be competitive. Actually, students suggested that additional competitive features should be added to the experience.

Thirdly, student engagement was assessed using informal measures, but a more formal evaluation, such as that proposed by Handelsman et al. [37], should be performed in order to have a richer understanding on this subject.

VI. CONCLUSIONS

Gamification is a novel technique that applies game elements to non-game contexts, to engage users and solve problems. In our experiment, we applied this to a traditional MSc course by adding game elements including points, levels, leaderboards, challenges and badges. While the first two serve the main purpose of displaying progress and providing feedback, challenges and badges give students the autonomy to pursue different goals. On the other hand, the leaderboard together with the course forums promoted relatedness and competition. We compared many aspects of the learning experience between a non-gamified and the gamified version of the course, on two consecutive years, and assessed their impact on student performance and satisfaction. Results were very positive, showing significant improvements in lecture attendance, which is optional, number of downloads of lecture slides, and number of posts on the course's forums. This suggests that students paid more attention to support materials, that they had more interest in lectures and that they were more engaged in the course. This engagement is particularly noticeable by the increase in post activity. Not only did students gave 511% more replies to other posts, but they also initiated 845% more threads, which denotes remarkable improvements both in participation and proactivity.

Challenges proved particularly effective in encouraging users to participate in forums and perform tasks they would typically avoid, like reading slides and suggesting reference materials. However, these have to be carefully tailored in order to be meaningful or they will be ignored. It is also important to assure that challenges are evenly spread throughout the term and are not concentrated in a particular period. This causes students to expect many instant gratifications and become bored when they become scarce. Creative tasks and multi-level achievements can boost student autonomy and render the whole experience more fun and compelling.

When compared to other courses, students found MCP to be more motivating and interesting, although they have admitted that it required more work. This suggests that students will feel more engaged with courses using gamification, even if that translates to a higher workload. Here, gamification, and our approach in particular, stand out by their potential to encourage students to become more diligent and dedicated to the course. However, we are yet to find a correlation between gamification and student grades, which is an interesting topic for future research.

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