Improving participation and learning with gamification

- # INTRODUCTION

  In the last decade, the use of technology to improve learning and education has been widely explored, as a means to improve instruction delivery. Gamification relies on the motivational power characteristic of good games which, unlike traditional learning materials, can deliver information on demand and within context [12] , balancing challenge difficulties according to one's abilities. Gamification has been used in many domains, such as healthcare, productivity and ecology, but its benefits to the learning experience when applied to education remain unclear. Here we present a new study where a new gamified trial of the course was deployed to gather additional student data. Do students perceive the gamified editions as more motivating and interesting? How did the gamified experiment affect the grades?

- # How was student engagement affected by the second gamified edition of the course?

  Answering these questions provided deeper insights into how gamification can be applied to education, improving student engagement and learning outcomes.

- # RELATED WORK

Previous experiments show that games can improve one's learning outcomes, motivation and diligence. In another study where videogames were used for homework as part of a numerical methods course, results suggest more "intellectual intensity, intrinsic motivation, positive effect and overall student engagement" [4] . For instance, Fitocracy 1 uses game elements like points, levels, badges and challenges, as well as a strong social component, to encourage users to work out and stay in shape. Gamification has also been used to motivate people to learn and train new skills. Progress is rewarded with energy points and badges. While systems like these have been used in flipped classrooms [24] , empirical data to vouch for this kind of method are lacking.

THE MCP EXPERIMENT

MCP is an annual semester-long MSc course in Information Systems and Computer Engineering at Instituto Superior Técnico. The course runs synchronized across two college campuses, Alameda and TagusPark, and follows a blended learning program, in which students attend live theoretical lectures (3 per week) and work on projects in laboratory classes (1 per week), but they also engage in discussions and complete assignments in the course's virtual learning environment (Moodle 5). The theoretical lectures cover multimedia concepts like capture, editing and production techniques, multimedia standards, Copyright and Digital Rights Management. In lab classes, diverse concepts and tools are taught on image, audio and video manipulation, and there are regular assignments. Measures like these have been used before to informally assess student engagement [16] .

Grading

Course evaluation varied slightly over the years, but the evaluation components were consistent. In the three nongamified years, typical course evaluation consisted of regular quizzes (25% of total grade), lab evaluations (20%, 20% and 15%), online participation in the course's forums (10%, 10% and 5%), a thematic multimedia presentation (20%), a final exam (25%, 25% and 35%), and 5% extra for lecture attendance. The final grade ranged from 0 to 20, with a passing grade of 10. In the two gamified years, instead of grade points, students were awarded experience points (XP), by meeting traditional evaluation criteria. Overall, the evaluation methods were similar, with achievements replacing the online participation and attendance bonuses in gamified editions.

- ## Gamified MCP 1.0

The main motivation to gamify the course was to improve student engagement and make it more interesting. By clicking a row, the achievement history for that player was shown, which made progression transparent and allowed students to learn by watching others. Challenges were tasks students had to complete to be granted XP and achievements. A special case of Theoretical Challenges were the Online Quests, which were more demanding, not particularly bound to any lecture, and with a longer deadline. The whole scoring process was done manually. The rationale behind the selection and integration of game elements with the course was thus based on SDT: Autonomy was promoted by providing options on what challenges to pursue and which achievements to level up.

- ## Gamified MCP 2.0

In the academic year of 2011-2012 we performed another experiment. Our gamified course was improved based on student

feedback from the previous year, with two new achievements to reward cooperation in the labs and one to reward oral participation. Additionally, a new achievement rewards students for timely responses to challenges and another rewards students for compiling challenge results. We also had critiques about the achievements being too much trouble for only 10% of total grade, which made us re-grade the course so that quizzes would be worth 10% less and achievements 10% more. For cosmetic purposes, we changed the amount of XP per level from 900 to 1200 XP.

THE SECOND TRIAL

In the first gamified experiment, we saw significant improvements in lecture attendance and in the number of downloaded lecture slides, with the most gains in both initiated threads and reply posts on the forums. We analyzed data from five academic years, beginning in 2007-2008 and ending with 2011-2012, with the last two being gamified years. Student data in both experiments was collected in an uncontrolled environment. Variables like the composition of taught subjects, support materials and faculty staff could not be manipulated, as some of these changed and evolved on a five-year time span. Since our data did not appear to follow a normal distribution, all statistical differences between groups were checked using the non-parametric Kruskal-Wallis and post-hoc Mann-Whitney's U tests with Bonferroni correction. We have also collected qualitative feedback from students with a questionnaire by the end of each gamified experiment, which we will also present.

Lecture Attendance

We saw significant differences in mean attendance by student over the years (Kruskal-Wallis test, $H(2) = 20.14$, $p < 0.001$), with

these being between 2007-2008 and 2010-2011 (Mann-Whitney's U, $p < 0.05$), respecting to an increase by 12% (see Figure 2), and between 2010-2011 and 2011-2012 ($p < 0.05$), reflecting a decrease of 11%. The lack of significance across years, and mainly among the gamified ones, seems to contradict our previous finding that student attendance would increase significantly with our approach. In 2010-2011 this correlation was weak and less significant ($\rho = 0.29$, $p < 0.1$) and in the non-gamified years there was no correlation ($\rho <= 0.1$, $p > 0.1$). We saw a similar pattern comparing lecture attendance with student posts on challenge threads, with a moderate correlation ($\rho = 0.47$, $p < 0.001$) not previously seen. This suggests that a positive correlation between lecture attendance and posts might be an emergent trend, but this matter requires further study.

- ## Support Material Downloads

The number of downloads of lecture slides, normalized to the number of students, presented significant differences (Kruskal-Wallis, $H(2) = 20.14$, $p < 0.001$) between every gamified and non-gamified year (Mann-Whitney's U, $p < 0.05$). Both gamified years presented an average of 4.17 normalized downloads per lecture, which is almost twice as much as the 2.32 seen in 2009-2010, and tree times more than the 1.2 and 1.41 seen in 2008-2009 and 2007-2008 (see Figure 3). Considering all support materials in the course, the numbers were less enlightening (see Figure 4). We clearly have two cases where the number of mean downloads per student were above normal, but since these correspond to a nongamified and a gamified edition, with three years apart, it is hard to evaluate the impact in this measure. Differences in course materials over the years might be behind this effect.

- ## Posts on Forums

We found significant differences in mean posts by student (Kruskal-Wallis, $H(2) = 141.20$, $p < 0.001$), between every non-gamified and every gamified year, and between gamified years (Mann-Whitney's U, $p < 0.05$). This effect can be explained by the significant increase in the number of reply posts by student (Kruskal-Wallis, $H(2) = 53.18$, $p < 0.001$) between the same years (Mann-Whitney's U, $p < 0.05$), and indicates that most of student participation consists of replies to other posts. This was expected as students have more opportunities to reply to others (e.g. challenges) than to create new threads. These differences denote a significant increase of student proactivity in the gamified years, which were 3 to 4 times bigger when compared to the non-gamified year with the most first posts. This effect can be in part explained by challenges being more attractive in the second year, as there were more of them and they were worth more. We saw a significant increment of 55% (1.08 vs.

- **1.68) in the amount of posts per challenge thread**

normalized to the number of students, between the two gamified years, although this result has limited significance (Mann-Whitney's U, $p < 0.1$). This indicates that student posts increased, not only because there were more challenges, but because they posted more per challenge. We found an interesting moderate correlation between the amount of challenge posts and the amount of posts on forums that would not reward students with XP, both in the first (Spearman's coefficient, $\rho = 0.40$, $p < 0.05$) and the second gamified years ($\rho = 0.53$, $p < 0.001$). These results imply that students that participate more on challenges might as well participate more on non-rewarded activities, which points to increased engagement. However, these differences were only significant between 2008-2009 and 2011-2012 (Mann-Whitney' U, $p < 0.05$).

Grades

Final grades were significantly different (Kruskal-Wallis, $H(2) = 24.55$, $p < 0.001$) between 2007-2008 and 2011-2012, 2008-2009 and 2010-2011, and 2010-2011 and 2011-2012 (Mann-Whitney's U tests, $p < 0.05$). While the first gamified year presented a grade drop, only significant relative to one non-gamified year, the second gamified year presented a significant improvement relative to both the previous year and one non-gamified year (see Figure 6). While it is not consistently significant, the second gamified year presents the highest mean final grade by student ever seen. Moreover, we had the maximum relative amount of students reaching the top grade ever seen, as depicted by the yearly progression of 2%, 6%, 0%, 0% and 11.5%. While trying to identify which grading components were responsible for the final grade growth between gamified years, we saw similar improvements over quiz, lab, multimedia presentation and final exam grades, but with no statistically significant differences. In particular, theoretical challenge posts seem to be strongly correlated with the final grade in the first ($\rho = 0.61$, $p < 0.001$) and second gamified years ($\rho = 0.58$, $p < 0.001$), and also moderately correlated with quiz grades in both 2010-2011 ($\rho = 0.50$, $p < 0.01$) and 2011-2012 ($\rho = 0.45$, $p < 0.001$).

Student Feedback

By the end of both gamified semesters, we carried out a questionnaire to gather qualitative student feedback about the new learning experience, where students had to rate statements using a five-point Likert scale. We got 28 answers in the first gamified year and 46 in the second. Taking a look at the answers' mode, students considered that the gamification experiment applied to the MCP performed very well (4 in both years) [1terrible; 5excellent]. When compared to other courses, they considered the MCP course to be more motivating (5 in the first

year, 4 in the second) and interesting (4) [1-much less; 5 -much 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 while in the first year they had not a clear opinion on whether achievements should account for more of the course grade or not (3), most of them though it should on the second year (4) [1-definitely not; 5 -definitely yes].

- ## The New Achievements

The new achievements had limited success. Those targeted at promoting cooperation were underused. Groups with good performance often blamed those with lower for the XP that had not been awarded. As compiling challenge results was too much trouble for only 100 XP, only one student undertook this task. The achievement for timely responding to challenges was highly criticized for promoting fast responses over meaningful posts.

- ## DISCUSSION

With our thorough analysis completed, we can now return to the research questions described in the introduction.

- ## Does our new data support our previous findings?

Contrarily to what we have previously found, we could not observe a consistent increase on student attendance in both gamified years. Our approach seems to have no effect on attendance, which might be explained by most gamification occurring over online content. However, the number of downloads per student had a significant increase on the first gamified year,

but in the second it went back to values similar to the nongamified years. It is hard to draw conclusions here but, ultimately, it suggests that students can be engaged to pay attention to course material as long as it is rewarded, like many other aspects of the experience. This derives from significant increases in both reply posts and initiated threads.

- ## How did the gamified experiment affect the grades?

  Although our second gamified year presented the highest final grade to date, we lack statistical evidence to support a significant increase. It may also explain, in part, the differences in the learning outcomes between experiments. We found that in both gamified years there was a strong correlation between theoretical challenges and final grades, and also a moderate correlation with the quiz grades. Given that both quizzes and theoretical challenges are forms of continuous assessment, that both cover broadly the same topics, and that quiz grades slightly improved from the first to the second experiments, we hypothesize that theoretical challenges might help students to study and get better grades on continuous assessment components, like the quizzes. This seems to support the benefits of using challenges to boost both student engagement and learning outcomes.

- ## How was engagement affected by Gamified MCP 2.0?

  Both experiences suggest that students were more proactive and participative in our gamified course, and that attention to reference materials might be positively influenced, which suggests a deeper engagement. This is corroborated by the students' opinion that the course was more motivating and

interesting than other non-gamified courses. One might argue that students posted more because they had more challenges to attend, but data shows they posted 55% more per challenge thread. Also, we found a moderate correlation between the number of challenge posts and non-rewarded posts, and this correlation grew from the first to the second experiment. This is an interesting topic of future research.

Study limitations

Our study has four major limitations, most related to variables we could not control. First, the student population was different from one year to another, which might have influenced the results. Given that lab instructors only dealt with students directly once a week, were not liable, and had limited intervention in the course, we argue that the inherent effect might be neglectable. Given the significance penalty these limitations entail, our results must be taken with caution. In the future we would like to study the possibility of reproducing the experiments in a controlled environment and perform formal engagement validation.

CONCLUSION

In this paper we presented a gamified course and discussed how gamification can be used to improve student engagement. Although lecture attendance seems to be unaffected, results showed that with our gamified learning experience students participated more and were more proactive in the forums, and also paid more attention to the lectures' slides, which suggests a deeper engagement. Our study also suggests that evening out challenge distribution over the term and making them fairly rewarded might significantly improve student participation and performance. Students seem to score better with the gamified version of the course and grade differences between them seem

to decrease. For future work we would like to further study the impact of our approach over student outcomes and perform a formal engagement evaluation.