A holistic gamified experience for engineers

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Abstract

The goal of gamification in education is to favor the student engagement with their own learning process through game elements oriented to enhance the students' motivation. We conducted a gamified experience of the Waves and Electromagnetism course of various engineering degrees at the University of Oviedo, setting the subject in a fictitious company in which the students conducted face-to-face and non-face-to-face activities to promote in the enterprise (and therefore in their knowledge). We observed a correlation between the participation and the grades obtained by the students, which is a possible consequence of the improvement of actively participating students' learning. The students' comments about the experience facilitates their engagement with the subject and enhance their self-motivation, and results in an aid for a better learning as well.

Keywords: polytechnic education, motivation, critical sense.

Introduction

Gamification experiences in education are oriented to motivate students to accomplish certain learning goals (Kapp, 2012; Marczewski, 2013; Contreras Espinosa et al., 2016) using elements from games, which can be classified into three layers (Kevin Werbach et al., 2012): dynamics, framework that provide the interplay of players with other players and with the game itself (for instance, the narrative, emotions, the relationships between players, constrains...); mechanics, rules that drive the game (competition between players, rewards, difficulty levels...); and components, objects and specific features that implement the mechanics and dynamics (gifts, experience points, quests...). Although mostly of the gamified practices in Spanish universities are partially gamified (by including components in some of the learning activities, such as a classification of students based on performance on a task), a few completely gamified experiences have been presented (Contreras Espinosa et al., 2017; Pérez López et al., 2017) that facilitate the students learning process through their motivation, but also improves the lecturer's motivation.

In the design of an education project, together with the activities developed in the context of the subject, the lecturer must examine the way in which the students participate in their learning, for which the students' motivations play an important role. Two kinds of motivation are distinguished: intrinsic (the person finds an activity rewarding per se) and extrinsic (the person performs an activity for reasons other than the activity itself) (Kapp, 2012, Friedrich et al., 2020). According to the Bartle (1996) model based on motivations, players can be classified into: explorers, attracted by discovery; assassins, involved in competitions; sociable, looking for interaction with other players; and achievers, interested in rewards.

With this work, the authors looked for to facilitate the students' learning of the *Ondas y Electromagnetismo* subject for telecommunications engineers taught at the University of Oviedo by promoting autonomous learning and collaboration between participants through a holistic gamification of the subject, embedding it in the context of an engineering company. The academic results of the two previous courses shown an average of 44% passed (of the total enrolled), with a participation rate of 39% in non-compulsory activities. In fact, a positive correlation between participation and the final grade can be observed: for example, when the students do not take the exam, they have a 0.91 probability of not having participated in the non-compulsory activities. On the contrary, when they actively participate, the probability of taking the exam is 1 and the average final grade is larger. In view of this analysis, it is assumed that increasing student participation produces an improvement in the understanding of concepts, which translates into motivation to take the exam and in higher grades as well.

Methodology

Ondas y Electromagnetismo subject belongs to the Basic Training module framed in the second semester of the first year for Engineering in Telecommunications Technologies and Services. Students are mainly between 18 and 20 years old with a medium-high level of digital skills. To achieve the objectives of the work, a gamification system that favors participation regardless of the preferences and difficulties presented by the students was designed based in a wide variety of activities so that each participant can select their personal learning path. The subject is set in the telecommunications company AsturSpace, which is conducting the Maxwell Program to provide internet and telephony access in areas of difficult coverage. Students play the role of employees and carry out activities included in three projects of the program related to the subject: design of a feeding system (topics: electrostatics and electric currents), analysis of a telematic control system (magnetostatics and varying magnetic fields) and design of a telecommunication system (oscillations and mechanical waves). The subject teachers perform the role of C.E.O. and design area director of the company and are in charge of proposing, directing, and evaluating the tasks of each project.

The activities developed were individual in nature (self-assessment test at the end of each teaching unit, questions in theory classes and subsequent public discussion, solving exercises on the blackboard, helping classmates who were doing an exercise on the board, finding bloopers on the transparencies, and ask questions and solve doubts of classmates in the forum) and in teams (crosswords and research projects). Depending on their involvement with the tasks, the students gained experience that allowed them to reach positions of responsibility with their respective salaries (active participation, AP, grade): all started at the Student level, and the higher levels are Graduate (0.25 points), Scholarship (0.5 points), Junior Engineer (0.75 points) and Senior Engineer (1 point). Additionally, four Project Manager positions were awarded (1 PA point, 0.85 exam grade points). In order to be promoted and stay in the position, the students needed to also reach a certain influence level, which increases when they win challenges with students or reached the position of Junior Engineer and decreases when they violate the rules of the company. Members of the same team were also allowed to exchange influence. To select the groups (four members), the students were left free.

A personal interview (in tutoring or by sending a presentation video) was conducted to find out their interests and motivations, a basic knowledge test between the first and second weeks of class to determine the knowledge level of the group, and a follow-up interview to evaluate the development of the project in the middle of the course.

Results and discussion

There were 62 students enrolled in this course, of which 43 have participated in the program (69%). It should be noted that none of the students who have decided not to participate in the project have chosen to get AP points through the proposed alternative. Discounting the number of students who have not participated in the compulsory activities (five students), the effective participation percentage is 74%. In general, the interest shown by first-time students has been high; the repeaters, on the other hand, have participated at a lower level (approximately 50%). The number of students whose level of involvement has been high (reaching at least the Junior Engineer level), has been 54%, which indicates that the interest has been maintained over time in most of the students. However, the percentage of students who have not reached the minimum of experience to earn a non-zero PA grade is significantly high.

To analyze the effect of participation on the final grades, the grades have been grouped by AP score (or, equivalently, by the level of experience achieved, see previous section). In Figure 1 it can be seen that, as participation increases, the rating also increases with a slope of 3.7 (which implies that, if the relationship between both magnitudes were perfectly linear, a high participation would increase the rating by 100% compared with the score of a non-participating student).

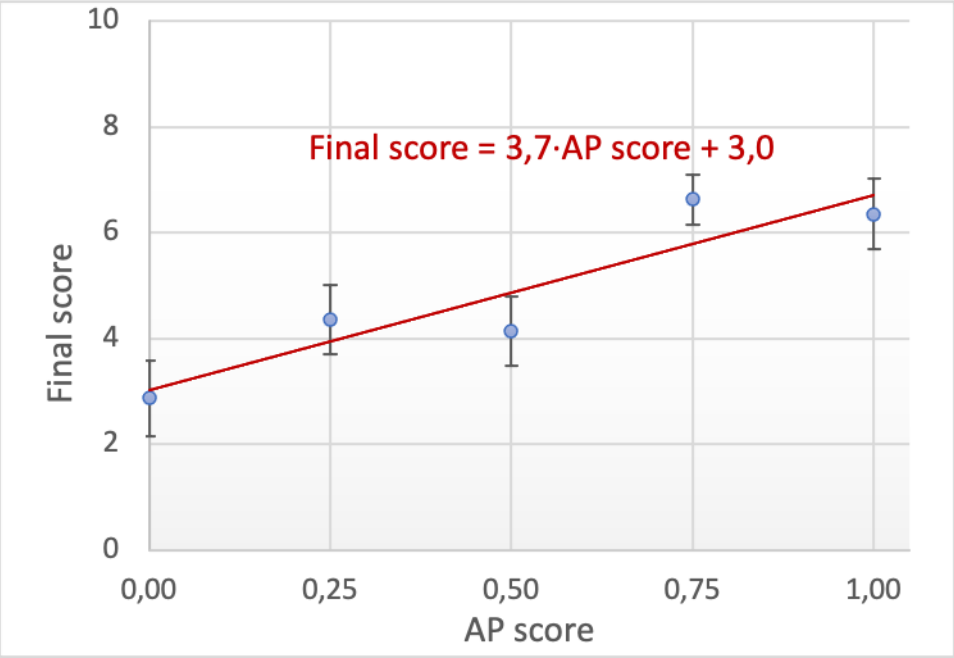

Figure 1. Average and standard deviation of students' final grades based on participation.

Within the proposed activities, the self-evaluation would allow obtaining information about the student's learning. However, an abrupt drop in participation occurred from the fourth test. This fall coincides with a period in which the students accumulated a fatigue due to the partial exams of other subjects; This coincidence, together with the fact that these tasks did not provide points of experience or influence, would lead to the loss of intrinsic and extrinsic motivation of the students respectively, causing students to focus on more productive tasks in terms of accumulating experience or improving their marks through midterm exams in other subjects. Another possible explanation could be that students would not see the relationship between self-assessment tests and improved learning; To analyze whether this would be a valid explanation, the same tests were opened once the Maxwell program had finished. Although the number of students who made use of these tests was not high, it was significantly higher (with increases of 700%) compared to tests 5-7, so it seems that, once the students are focused on the preparation of the subject, they are inclined to use these tools for the benefit they perceive that they can provide them in terms of qualification in the subject.

Regarding the students' perception of the program, a survey was performed in which they were asked about aspects of the program. On average they have answered that the experience has been satisfactory. However, this survey was fulfilled by only eight students, so the information that can be extracted is qualitative. From the interviews carried out in the teacher's office, several interesting comments can also be extracted:

- The program motivates them to go to class, because it is affordable to obtain AP scores.
- It forces them to take the subject relatively up to date.
- In general, the students are satisfied with their group. In fact, they wish there were more group activities.
- They do not like to explain the exercises on the board, mainly because their insecurity.

They were also asked in the interviews about the perception of their competences; while the majority (73%) pointed to teamwork as a competence in which they had improved, only a testimonial amount (22%) managed to improve in communication (oral or written). This could indicate that they are not used to teamwork and are used to expressing their ideas.

Conclusion

A gamified experience of the *Ondas y Electromagnetismo* subject for telecommunications engineers was designed and put into practice from a holistic perspective to improve student learning through participation in different activities that combine information and communication technologies with game resources as intrinsic and extrinsic motivators.

From the analysis of the experience, active participation makes it easier for students to pass the subject thanks to a more complete learning of the subject matter, and a clear correlation between the participation and final score is obtained.

Regarding the perception of the students, the questionnaires fulfilled indicate that the experience has been, in general, positive. Although initially the students perceive that the system is confusing at the beginning of it, the majority declare a better impression at the end of the course. In this sense,

the students have valued the change in learning methodology very positively, improving their commitment to the subject.

These results point out that the effort involved in the design and implementation of an experience of this type is worth it because there is an improvement in learning and the positive feelings expressed by the students.

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