Using gamification to increase learners’ engagement in MOOCs

Pedro Filipe Martins Rosado Dias
Técnico Lisboa, University of Lisbon
Lisbon, Portugal
pedro.rosado.dias@tecnico.ulisboa.pt

ABSTRACT
Massive Open Online Courses (MOOCs) stats to have exceptional learning circumstances in higher education. Nevertheless, one of the main problems found in MOOCs is the low degree of engagement, which can be reflected in the low participation in the course activities. According to our research, this problem may be solved with an increase in students’ engagement based on motivational theory. Gamification can play an important role in the theory of self-determination, and it is stated as a good way to raise extrinsic and intrinsic motivation through the application of game mechanics. Gamma Técnico is a gamification software that was installed in the MOOC Técnico platform, aimed to increase user’s activity and retention through game elements. To evaluate whether this is true, two demonstrations were performed. From the collected data, we analysed the software’s performance in an attempt to solve the low degree of learners’ engagement in the near future.

Author Keywords
MOOCs; Gamification; Game Elements; Learners Engagement; MOOC Completion Rates; MOOC activities.

INTRODUCTION
Massive Open Online Courses (MOOCs) is an emerging phenomenon resulting from a transformative higher educational paradigm. Firstly introduced in 2008, then MOOCs emerged as a popular mode of learning in 2012 and since then they became a widely researched development in distance education.

During the past years, a considerable number of platforms have emerged such as edX\(^{1}\), Coursera\(^2\) and Udacity\(^3\), which offers MOOC courses with an unlimited number of participants to learn together through the web. In particular, Open edX\(^{4}\) an open-source platform developed by edX was made available in 2013 to every Higher Education Institution (HEI) that desired to make similar offerings, allowing them to create their own local instance of Open edX such as Lagunita Learning Platform\(^5\) at Stanford, among other. Given the increase of its use, there is a greater need to study online platforms, to overcome challenges that had eventually emerged.

Students’ engagement, which refers to how learners engage with content, began to be investigated in more recent decades. Energized by motivation, as explained by Self-Determination Theory (SDT), it is a prerequisite for learning. Also, it is one of the challenges generally faced by MOOC platforms since the majority of the participants don’t feel committed to interacting with the content of the courses.

Now, more than ever, due to the global pandemic of COVID-19 that we are facing, these e-learning platforms potentialized their usage. One can read in the 2020 Class Central’s report\(^6\) that one-third of the learners that ever registered on a MOOC platform did that in 2020, making 2020 “The Second Year of the MOOC”, with 31 million new registered users in Coursera, and 10 million in edX.

MOOCs became a higher necessity for every HEI to facilitate student learning and provide social care and interaction during long periods of school closure. Some universities, as Instituto Superior Técnico (IST), also started using these platforms as a way to both enable students with a better way to follow the course contents as to allow students to get evaluated through exams, in an online format.

Research Problem
The low completion rates and learners’ engagement in course activities are some important issues that teachers and MOOC tutors try to get an answer to, from the beginning of the MOOC movement [6,19] until recently [1]. In a total of 221 MOOCs, analysed [15] in the trends of "enrolment and completion of MOOCs", Jordan has verified a completion rates variation from 0.7% to 52.1%, depending on their duration and the platform strategies in where they were launched, with a median value of 12.6%. The low

\(^{1}\)https://www.edx.org/
\(^{2}\)https://www.coursera.org/
\(^{3}\)https://www.udacity.com/
\(^{4}\)https://open.edx.org/
\(^{5}\)https://online.stanford.edu/
completion rate is verified in several types of MOOCs, in particular in the areas of STEM. Addressing the completion rate and the interaction with content materials from a design perspective is a pedagogical issue and a challenge for designers and instructional instructors to leverage open education [15]. Thus, the main problem addressed in this dissertation is the low degree of learners’ engagement, particularly in STEM MOOCs.

Research Proposal
In recent years, gamification has become a trending topic in different areas. More recently, it has gained special attention in its possible applications in educational contexts [24]. Having the potential to foster users engagement levels with content and improve positive learning patterns, game elements can be used to increase learners' productivity and raise the number of different types of activities, such as the number of social interactions [12]. Since we believe gamification can be part of the solution to increase participants' engagement in open online courses, our proposal will be to apply game elements in MOOCs to achieve this goal and contribute to higher completion rates.

Research Methodology
To guide our research on the use of gamification on MOOCs we used the Design Science Research Methodology (DSRM), which provides consistent guidelines for the design and accomplishment of high-quality design science research projects in the Information Systems (IS) field [21].

RESEARCH BACKGROUND

MOOCs
The acronym MOOCs stands for Massive Open Online Courses and was firstly coined by Dave Cormier in response to an open online course produced and led by George Siemens called Connectivism and Connective Knowledge in 2008 [20] and it has been widely used since then.

The term stands for the four most relevant and unique properties of these courses: They are Massive because they are extremely easy scalable to support theoretically an unlimited number of participants. Open, since anyone can participate due to the ease of access and lack of requirements for registration. They are Online because the asynchronous or synchronous access to the course materials is made through the internet. Last but not the least, the term Course involves a discussion on a domain theme categorized by having start and end dates [16]. These attributes qualify MOOCs to have a great pedagogical potential to make education available to everyone with access to the internet.

MOOCs in Técnico Lisboa
MOOC Técnico\(^7\) is an example of a MOOC platform used by IST to facilitate the spread of knowledge and as a tool for flipping the class strategies since 2016. With more than 20240 registered users\(^8\), this platform offers more than 20 free online courses on various topics of STEM, available at different levels of training. As previously identified, a major problem identified in MOOCs is the learners’ low degree of engagement, in particular, in MOOC Técnico online courses, mainly the ones that run in a self-paced mode, the same problem can be observed.

In 2018, the platform recorded a completion rate on the MOOCs ranging between 25% and 58% [26] and in 2020 the average completion rate is greater than 30%, which is considered to be very encouraging results compared with the usual averages [2,5].

Engagement
Here we focus on engagement in the context of learning, so we adopt Kuh et al. definition of student engagement as “participation in educationally effective practices, both inside and outside the classroom, which leads to a range of measurable outcomes” [17].

According to Glossary of Education Reform\(^9\) “in education, student engagement refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education”. A high level of engagement results, in general, in high-quality learning, letting the learner be emotionally connected and satisfied with the course and the institution, while the opposite results in disaffection [18].

The Universal Design for Learning Guidelines
Universal Design for Learning (UDL)\(^10\) is a framework designed to enhance instructors and teachers to meet all learners needs. By recognizing that all learners have different needs and strengths it's possible to minimize any potential learnings barriers and improve the learning experience [3,7]. Engagement, the main principle we will be focusing on, represents an important element in learning, which according to the UDL framework, answers the question "Why should students learn this content?". We can see in the picture that this principle also helps addressing subjects such as "How to get students to actively engage in learning?" or "How to motivate students to give effort?" and even "How to help students monitor their own progress?".

UDL Guidelines are relevant principles to apply in several cases, such as the concrete case of MOOCs, containing a manual of good practices that should be considered when building an online course [13].

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\(^7\) https://mooc.tecnico.ulisboa.pt/

\(^8\) Last updated on July 31, 2021

\(^9\) https://www.edglossary.org/student-engagement/

\(^10\) https://udlguidelines.cast.org/
**Self-Determination Theory**

Self-Determination Theory (SDT) is considered to be a widely applied theory of motivation, personality improvement, and wellness in the field of psychology due to its scientific approach to human motivation and confirmed practice in multiple domains [23].

Basic Psychological Needs Theory [23], a fundamental mini-theory within the more comprehensive framework of SDT, established autonomy, competence, and relatedness as the three fundamental psychological needs that promote psychological wellness, which is considered to have huge implications on healthy self-development.

Intrinsic motivation [23] demonstrates the character of human nature and the spontaneous propensity of people to get interested in a world with the objective of interaction, master, understand or engagement. In contrast, extrinsic motivation [23] aims to achieve outcomes separable from the behaviour itself.

Being applied in a variety of areas such as Education, Healthcare, among others, SDT justifies why how autonomy-supportive techniques, and others, can influence motivational and performance outcomes.

**Gamification**

During the last years, the term gamification [8] has emerged and has been a trending topic since then. Here, we adopt Deterding's definition of "Gamification" as the use of game design elements in non-game contexts [8].

Gamification stands on the theory of self-determination where the two types of motivations, mentioned above, are identified: extrinsic and intrinsic motivation [10]. It is suggested in some studies [10] that the incorporation of gamification methodologies can increase participants' motivation, through the use of game mechanisms, and increase the learners' participation, commitment and loyalty in a course and consequently may result in a bigger number of proactive participants. Thus, the conjugation of these factors may affect positively the dropout rate and increase participation throughout the course [10].

**Game design elements**

Based on a recent systematic literature review carried out to identify the impact of gamification MOOCs, as well as the different success metrics being used, from the list of top 5 most used elements we have [9]: badges; leaderboard; levels; points and forums. Given the existence of several types of players, all game design elements should be considered before applying them to a specific purpose, such as in Education.

From all these elements, we would say that badges and leaderboards have the potential for increasing engagement in STEM MOOCs. Usually awarded through status icons such as medals and trophies, it seems to encourage some desired online behaviours, providing status and recognition [11]. On the other hand, a leaderboard allows users to compare their performance within an established online community. The use of this element in the education field shall be treated carefully since it can reinforce stereotypical behaviours and be harmful to some learners’ confidence [4].

**PROPOSAL**

**Objectives**

The main goal of this research is to verify how gamification techniques can be used in MOOCs as a way to increase learners’ engagement in online courses, in particular on STEM subjects.

**Description**

We propose to apply different gamification techniques in a specific MOOC provider to access whether we can increase learners’ engagement in online courses.

We defined a set of steps, which will be listed below, by which we will support the application of gamification in any MOOC provider.

- Step 1: Choose the game elements to apply;
- Step 2: Adjust the game elements to the experience;
- Step 3: Prepare the experiment;
- Step 4: Run the experiment;
- Step 5: Collect and analyse the results of the experiment.

**DEMONSTRATION**

**Gamma Técnico**

MOOC Técnico was the chosen platform to perform this research since it is also facing the above-identified problem, and since during the execution of this dissertation, we were currently part of the team responsible for the support of this platform, which facilitated the accomplishment of this study. Based on research, performed at the beginning of this thesis, there were not many available gamification options to apply to the latest version of Open edX (Juniper version) thus, we opted over the only available one at the time, the Gamma project.

**Gamma Técnico Software**

Gamma Técnico is a gamification customized software, developed by Raccoon Gang [11] and installed in the MOOC Técnico platform by eduNEXT [12], according to our current production environment. Its a scalable microservice this limit can be increased as required. It is mainly composed of three main components: Gamma Bridge, Gamma Core and Gamma Dashboard. In resume, the four main game elements Gamma Técnico provides are points, levels, achievements and a leaderboard, which will be further detailed.

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11 [https://raccoongang.com/](https://raccoongang.com/)
12 [https://www.edunext.co/](https://www.edunext.co/)
This system can collect, by default, up to thirteen different events. Different points may be awarded depending on the activities carried out on the platform. It includes events or activities such as: video visualization, problem responses’ submission, distinct forum activities, among others. Depending on the number of points obtained so far, a user has the opportunity to ascend to different stages, obtaining a new status every time a new level is reached. These statuses are rewarded with an emblem.

Gamma Dashboard is mainly composed of two dashboard pages, accessible from the platform navigation menu: Performance and Leaderboard pages. The Performance page is an individual page for each learner, which allows the participants to have a better view, through graphics and diagrams, of the activities performed by them on the MOOC Técnico platform. Represented in a circular chart, users have a clear visualization of the points distribution given the different activities performed so far, and a Status Roadmap that represents the total points the users own and the points until the next status.

The Progress Tracker section organizes the user’s progress, distributing the collected points organized into different periods (day/week/year), allowing the learner to track their productivity in a timeline. When accessing the badges sections the user can identify the already achieved badges and the missing ones, as also as get the information of the needed points or activities to achieve them. On the other hand, the Leaderboard page lists a hundred users with the most points on the platform. For each user, the information concerning the user’s statuses and badges obtained are also presented.

**Gamma Técnico Data**
Gamma Técnico stores all Gamma events data in a Mongo database, mainly in two collections: event_history and users. In the event_history collection, all processed events regarding the users’ activities in the platform, in a JSON format, captured by Gamma Bridge and sent to Gamma Core are stored.

Also, in the users' collection, all data related to a given user is then stored, in a JSON format, such as the points, badges, statuses and progress collected so far, and all information needed to fill the charts shown on the Performance and Leaderboard pages.

**Gamma Técnico Setup**
Gamma Técnico was configured to capture ten different event types of the thirteen available, based on the most performed and most relevant activities on a MOOC, in the MOOC Técnico platform. Different points, from 1 (Bookmark added) to 100 (Certificate issued), were attributed to each captured event, taking into our consideration the relevance of those activities in the learning process and the average number of times that they may occur in a MOOC. Based on the awarded points learners can achieve up to five statuses were created to provide an idea of progression, and with designations that we took care to be inclusive. Organized in ascending order, the chosen statuses were: Initiated, Intermediate, Experienced, Proficient and Inspiring.

**First Demonstration**
**Drone Simulation and Control Course**
The Drone Simulation and Control online course (droneX) covers topics regarding the functioning of multirotor drones and the parts that constitute them, as well as the development of a simulator to analyse their behaviour and design solutions for their automatic control.

Counting already with three editions in 2018, 2019 and 2020\(^\text{13}\), this MOOC is recommended to students enrolled in the curricular course of Flight Control in IST, which stands in the third year of the Integrated Master’s degree of Aerospace Engineering. Being used as a complement for flipping the class, students enrolled in the face-to-face course are able to count their final score on the MOOC towards the final grade of the Flight Control course, at a maximum of 2 points (out of 20). The 1\(^\text{st}\) demonstration was implemented during the 2021’s edition\(^\text{14}\) of the droneX course.

**Procedure**
All students enrolled in the latest edition of the course were pseudo-randomly divided into two separate cohorts (control and test group). Both the control and test group learners were able to access the course contents on the platform, with the particularity that the test group users would also be able to access the Performance and Leaderboard pages. The division of participants into these two cohorts was performed trying to maintain a balance in the distribution of genders. Besides, in droneX, the distribution of learners also took into account the balance of students enrolled in the curricular courses (internal students) and external participants.

Weekly emails were sent to both the control and test group notifying them of the newly available contents in the courses as well as of the deadlines of the evaluation topics. Also, the test group also received supporting messages and additional information concerning the Gamma dashboards pages containing links to those pages, providing them with an external source of motivation to turn learners experience more engaging. The number of emails sent was taken into consideration so that each learner did not receive more than one email per week.

At the beginning and end of the course, enrollees were invited to fill in an initial and final questionnaire. The questionnaire for the test group also included an extra section related to Gamma Técnico. Later on, the data

\(^{13}\)https://courses.mooc.tecnico.ulisboa.pt/courses/course-v1:IST+droneX+2020/about

\(^{14}\)https://courses.elearning.tecnico.ulisboa.pt/courses/course-v1:MOOCs+droneX+2021/about
related to learners’ grades and Gamma Técnico data were collected. All collected information was then further analysed.

In addition to the primary procedure presented above, the following settings were applied to this 1st demonstration. Besides the Statuses badges, learners enrolled in droneX were also able to earn five different badges, based on the activities performed in this course: Gifted Communicator is a badge that rewarded learners who actively participated in the discussion forum, Problem Solver tried to reward proactive learners in assessment activities. Sensible Fixer badge granted to learners who seek to help answer questions raised in the forum and the Attentive Watcher is a badge that permeated participants who extensively watch the MOOC videos. Finally, the Major Organizer rewarded learners who use a lot of notes and bookmarks throughout the online course. These badges were provided to learners who performed some specific activities, in this specific edition of this course.

Results
On the last edition of the droneX course, a total of 182 learners enrolled in this course, most of them male (81.87%) but balanced in terms of affiliation to the curricular course of Flight Control.

Based on an initial questionnaire, a total amount of 127 answers were collected, we were able to get feedback regarding learners’ initial motivation for this course. On a five-point Likert scale, where 1 means ”none” and 5 ”quite a lot”, 101 of the replies were between 4 and 5.

This 2021’s edition had a final completion rate of 55%. When evaluating the completion rate between groups, the control group ended with a final completion grade higher than the test group (64% and 47%, respectively). Even in a lower number, female participants had a better performance in the course than males do, finishing the course with a better median result (1.0, compared to the median value of 0.67 from male participants).

When analysing the boxplot of course grade distribution by cohort and gender it’s clear that, in general, both male and female groups from the control group finished the course with a better median result than the male and female from the test group. Also, the male and female test groups’ boxplots presented a higher midspread.

With regard to the boxplots of grade distribution by cohort and affiliation (students enrolled in the curricular unit of Flight Control at IST and external participants), it is possible to observe that internal students performed much better than external ones. When comparing the results by cohorts, both subgroups of external and internal learners of the control group performed better than the equivalents of the test group.

Both internal student subgroups finished the course with an average score of 1.0 although, the control subgroup finished with smaller values variation, even with several identified outliers, ending up with a higher minimum value than the test subgroup. Concerning the external participants, the control subgroup finished the course with a higher median value (0.42) than the corresponding test group (0.20), with grades placed in a higher range.

With respect to the Gamma events produced by learners in the control and test group during this course edition, it's possible to observe that both groups have performed similar activities and in an equal number. The majority of the performed events were related to the visualization of videos and submission of problems and only a few were related to other activities.

Concerning the Bookmark Added events, it was not possible to establish a direct association to this course because the system doesn’t store this kind of event with a course association. Although by analysing the events performed only by learners enrolled in the droneX course, it's possible to verify that, in the course period, learners enrolled in the test group performed more bookmarks events than learners enrolled in the control group. Besides, it's even possible to identify that these events were only performed by four male learners, being three of them from the internal group. Since these students were only enrolled in this course at that time, these events likely took place in this course.

With respect to the badges available in Gamma Técnico, only the Problem Solver and Attentive Watcher badges were obtained by enrollees in droneX. The control group obtained a total of 33 Problem Solver badges against the 22 acquired by learners in the test group. On the other hand, 12 learners in the test group gained the Attentive Watcher badge versus the 9 learners in the control group. Internal students were responsible for the majority of the badges awarded in this course (around 70%).

In the final questionnaire we obtained a total of 68 replies. Regarding the questions about Gamma software, which were only available to the test group questionnaire, fourteen from the twenty-eight test group respondents answered that Gamma Técnico provided a good/very good user experience, and eleven respondents answered that the software had a positive/very positive impact on their motivation and on the course final grade. Also, twelve and thirteen learners, respectively, stated that Gamma Técnico had a positive/very positive impact on their interest and ability to acquire new knowledge.

Additionally, an interview was conducted with one of the tutors responsible for the droneX course, at the end of the MOOC execution.

Second Demonstration
Metal Air Batteries Course
The Metal Air Batteries course (metal_airX) covers the basic construction and the main recent applications of metal air batteries. Designed for Master students and researchers
with a special interest in energy storage, with basic knowledge of thermodynamics and electrochemistry, it ran for the first time in 2019\(^1\). The new 2021's edition\(^2\) of the metal\textsubscript{air}X course followed the same structure as its last edition.

**Dynamic Energy Budgets Course**

The Dynamic Energy Budgets course (deb\textsubscript{X}) covers a framework for modelling metabolism at the organism level, incorporating the full life-cycle, using the Dynamic Energy Budget (DEB) theory. This course counts already with several editions in 2017, 2019, 2019\(_{2}\), 2020 and 2021\(^3\). The 2\textsuperscript{nd} Demonstration was applied during the new edition of the deb\textsubscript{X} (2021\(_{2}\)) and metal\textsubscript{air}X (2021) courses. This new edition of deb\textsubscript{X} also followed the same structure as the previous editions.

**Procedure**

In addition to the primary procedure presented in the 1\textsuperscript{st} demonstration, the following settings have been applied to this 2\textsuperscript{nd} demonstration. This took place during the execution of the deb\textsubscript{X} (ed. 2021\(_{2}\)) and metal\textsubscript{air}X (ed. 2021) courses. The metal\textsubscript{air}X course ran from the 26\textsuperscript{th} of April until the 13\textsuperscript{th} of June 2021 and the deb\textsubscript{X} course ran from the 27\textsuperscript{th} of April until the 31\textsuperscript{st} of May 2021 both on the MOOC Técnico platform. At the beginning of the execution of these courses, the same badges applied in the 1\textsuperscript{st} demonstration have now been applied. Nevertheless, the events captured to obtain a certain badge could be held in any of the courses taking place on the MOOC Técnico platform and not just on that specific course, as it occurred in the 1\textsuperscript{st} demonstration.

**Results**

Firstly, the results of the metal\textsubscript{air}X course are analysed. On this last edition, a total of thirty-four learners enrolled in this course, most of them male (82.35\%). On the course initial questionnaire, we collected answers from a total of twenty-four volunteers (70.59\% of all participants). Regarding their initial motivation for this course, on a five-point Likert scale, nineteen learners stated to be positively motivated (between 4 and 5).

This last edition of the metal\textsubscript{air}X course had a final completion rate of 35\%. Also, this percentage remains the same when comparing the completion rate between the control and test groups. When analysing the boxplots of course grade distribution by cohort and gender, we verify that female participants from the test group had a better performance, finishing the course with a better median result, when compared to the corresponding control group (0.55 and 0.0, respectively).

The same does not apply to the male participants, where the median value was higher in the control group than in the test group (0.49 and 0.04, respectively). Also, more than 50\% of male learners enrolled in the test group had a final grade of 0, or close to, which contrasts with 36\% of the corresponding control group.

In respect of the Gamma events produced by learners enrolled in the control and test group in the metal\textsubscript{air}X course, it is possible to verify both groups have performed similar activities during this course edition. In general, we verify not much variety on the performed events, learners were more focused on watching videos and submitting problems. Concerning the Bookmark Added events, it was possible to collect all events performed by learners enrolled in the metal\textsubscript{air}X course. Since the learners that performed these events were enrolled in several courses at the time, we were unable to validate, with the necessary rigour, the origin of the events.

In the metal\textsubscript{air}X course, we were able to collect up to 15 responses to the course final questionnaire. Regarding the Gamma Técnico section, available to the test group, we observe that the opinions are divided. Half of the repliers affirm that Gamma Técnico had a good/very good impact on their motivation, interest, ability to acquire new knowledge and on the course final grade. The other half of the participants felt that the software had no impact on these fields. The same opinions division happened when asked if they agree with the idea of making this software available to the other courses. Half of the participants agree/strongly agree with this last idea, whether the other half remained indifferent.

Concerning the results of the deb\textsubscript{X} course, this new edition counted with a total of thirty participants, gender-balanced, being two-thirds of them enrolled in the curricular course of Applied and Landscape Ecology in IST.

From the nineteen volunteers' replies (55.88\% of all participants) to the initial questionnaire, we were able to identify that seventeen of the responders declared to be motivated/extremely motivated to this course.

This last edition of the deb\textsubscript{X} course ended with a final completion rate of 67\%. When evaluating the completion rate among groups, the test group ended with a final completion grade higher than the control group (73\% and 60\%, respectively). Most of the certificates (90\%) were obtained by learners enrolled in the IST curricular course (internal students). When evaluating the boxplot of course grade distribution by cohort and gender it's clear that female learners finished the course with better grades the male learners.

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\(^1\)https://courses.mooc.tecnico.ulisboa.pt/courses/course-v1:IST+metal\textsubscript{air}X+2019/about

\(^2\)https://courses.elearning.tecnico.ulisboa.pt/courses/course-v1:MOOCs+metal\textsubscript{air}X+2021/about

\(^3\)https://courses.elearning.tecnico.ulisboa.pt/courses/course-v1:MOOCs+debX+2021/about
When comparing the grades between cohorts, it can be observed that female participants of the control group performed slightly better than those in the test group, finishing the course with a median grade higher than the corresponding test group (0.88 and 0.8, respectively). Also, the females’ control subgroup got the highest lowest grade value when compared to the analogous test group (0.77 and 0.67, respectively).

In the male case, it's possible to verify that the grades are more distributed when compared to the females' case. Both male subgroups present a negative asymmetry although, the males' test subgroup presented a higher interquartile range when compared to the corresponding control subgroup. Moreover, we can verify that the male participants in the test group performed better than the corresponding control subgroup, finishing the course with a higher median than the control subgroup (0.28 and 0.15, respectively). Also, we can highlight that the third quartile value was also higher in the male's test subgroup than the corresponding control group (0.79 and 0.45, respectively).

Regarding the boxplot of grade distribution by cohort and affiliation, it's possible to conclude that internal students finished the course with a much higher completion than the external learners. When comparing the results by affiliation, we can notice a slight difference between cohorts in the internal groups' case. The internal control subgroup obtained a higher median result (0.91 and 0.84, respectively) and a higher third quartile value than the corresponding test group (0.95 and 0.91, respectively).

In the external group case, all learners in the control subgroup finished the course with a negative grade, while in the case of the test subgroup, this value was around 50% of all participants enrolled in this subgroup. Even though there is a large group of low grades in the test subgroup, there is also a good percentage of participants who are getting higher grades, when compared to the corresponding control group, the values are more spread out. We can therefore conclude that the external participants in the test subgroup performed better than the corresponding control group, even though the median is lower than the control subgroup (0.02 and 0.08, respectively).

Concerning the Gamma events, it is possible to observe that both groups had, in general, a similar number of activities performed thought this course run. Although, it's relevant to highlight the big difference in the number of Complete Video events performed by learners in the test group on the week of the 23rd of May, compared to the control group in the same week. Also, learners of the test group were the only ones to perform Forum Thread Created and Learner Note Added activities during this course.

Regarding Book Added events performed by learners enrolled in the debX course, we can see that the two Book Added events performed by the control group were conducted by a male internal learner, while the remaining events, completed by the test group, were held by two female participants also enrolled in the internal group. Even though it's not possible to track the course where these activities were held, we confirmed that, in this period, these learners only had access to the debX course, which allows us to conclude that these events were, in fact, accomplished within this course. In this case, here we remarked that the test group has in total performed more Book Added activities than the control group.

In the final questionnaire, we collected a total of nine answers (30% of all participants), three learners from the control group and six from the test group. Regarding the questions about Gamma Técnico software presented to the test group, the opinions seem to be divided. Half of the learners stated that Gamma Técnico provided a good/very good user experience whether the other half classified it as indifferent. The same division happened when classification the areas where Gamma Técnico has had a positive impact. Half of the responders stated that the software had a positive impact on their ability to acquire new knowledge and on the course final grade, whether the other half considered as indifferent impact. Concerning learners' motivation and interest, only two said that the software had a positive impact, while the rest considered it indifferent. In the end, four out of six, of the participants consider it a good idea to make this software available for the remaining courses on the platform.

At the end of the debX and metal_airX courses, only two male learners received the Problem Solver badge (out of the five available badges).

**EVALUATION**

To understand whether the gamified solution achieved the desired influence on learners, some metrics were defined to help us assess and measure learners’ engagement. The metrics we will use are the percentage of certificates issued at the end of the course (completion rate) and the number of different activities that learners can perform in a given MOOC, such as the number of completed video visualization, the number of posts on the course discussion forum, number of notes and bookmarks made, among others. These last activities were obtained and measured through the gamification software, Gamma Técnico.

**First Demonstration**

The first results of the first demonstration on Gamma Técnico were not very conclusive regarding the users’ final scores, we were expecting a higher influence on learners’ grades, even though the completion rate has improved when looking at the previous editions of the course. As in the previous edition female learners, even in short number, are performing better than male participants, and internal students are performing better than the external ones. An explanation for this last could be that the MOOC final score could count towards the final grade of the curricular unit “Flight Control”. Even though in a small percentage (maximum of 2 points out of 20), it seems to be working as
a relevant element of external motivation. We remark that the gender gap in completing STEM MOOCs is not a general observation [14].

Based on the answers to the initial questionnaire, it is possible to identify a high general initial motivation, however, it was not reflected in the learners' participation in the course. Concerning the detected lack of variety of performed Gamma Técnico events, this can be interpreted as a general deliberate behaviour of the participants to perform the least as possible of essential activities of the MOOC. Notwithstanding, the slight difference in the Bookmark Added actions of the test group compared to the control group, may indicate a positive influence of the gamification applied to this course.

Given that Gamma Técnico was only released two weeks after the start of the course (halfway through the course), we believe that it did not help participants to get used to the software, allowing them to use it in its entirety. This demonstration did not allow us to reach a very definite conclusion on how Gamma Técnico can influence learners' experience.

**Second Demonstration**

With the second demonstration, we obtained more accurate data on how Gamma Técnico software might interfere with learners' engagement. Regarding learners' final scores in the courses, it's relevant to point out that, in general, male participants obtain grades in a much more diverse range than female learners. When comparing the grades differences by cohort and gender, we can observe that in the metal_airX course, female participants of the test group got better results when compared to the control group of the same gender. The opposite happened in the debX course, where male participants of the test group got better results, than the corresponding control group of the same gender. Even though we cannot affirm with certainty that the verified grades variances were due to the application of the Gamma Técnico software, we believe that it is an indication of some phenomenon that deserves to be investigated.

Regarding the grades difference by cohort and affiliation, it's notable that, in the debX course, internal students got higher grades than external participants. This phenomenon might be explained by the fact that the MOOC grades were included in the continuous assessment (70% of the final grade) of students enrolled in the respective curricular course. Even in a qualitative way, this additional external motivation proves to be an element that positively influences students to obtain better results in MOOCs.

Concerning Gamma Técnico events, it was possible to verify that both the test and control groups of both courses (metal_airX and debX) carried out, in general, similar activities throughout the courses. The majority of the captured activities were related to the visualization of videos, submission of problems and course enrollments. The lack of variation in events reinforces, once again, the learners' aversion to having a more active posture in online courses, performing only the minimum and indispensable activities to obtain approval for the courses.

Regarding the learners' opinions about Gamma Técnico software, opinions are generally divided. Half of the participants, who participated in the final questionnaire, considered that the software had a good/very good influence on their motivation, interest, ability to acquire new knowledge and on their final grade, while the other half considered having indifferent impact. Learners seem to be enjoying using the Gamma Técnico software, and some of them even seem to be taking positive advantage of it. As there is no negative feedback, apparently the software does not appear to negatively affect participants engagement and performance, which in itself is a very positive point to remark.

**Discussion**

To evaluate the achievement of the main objective of this research, we selected some of the most used criteria proposed by Prat et al. [22]. The chosen criteria are efficacy and utility (Consistency with People). To measure the efficacy of the artefact produced in increasing learners' engagement in MOOCs, we took into account the initial metrics defined to assess engagement.

Regarding the completion rate metric, it is possible to verify that this was only successfully achieved in the debX course. It was the only course in which participants with access to the gamification software (test group) had a relatively higher completion rate than the corresponding control group. In the metal_airX course, we verified the same success rate in both groups, so we were not able to get any conclusion. Regarding the completion rates in droneX, we note that this metric was not met. However, we believe that because the gamification software was applied only in the middle of the course, it has limited participants' adaptation to the software.

Concerning the Gamma Técnico events metric, it's possible to observe a lack of diversity in the performed events in both experiments. Moreover, when comparing the events produced by both the control and test groups of all courses, it is not possible to establish a causal correlation between the gamification software and the activities developed by the participants enrolled in these MOOCs. These results, in our view, left the software's capabilities in engaging learners far behind, given the current constraints we live in as a consequence of the pandemic. Based on the above criteria we concluded the efficacy of our artefact was not fully achieved although, we believe there is still room for improvements.

To measure the utility of the produced artefact to people in its practical use, we will consider the responses to the questions related to Gamma Técnico in the final questionnaire, available to learners who had access to the gamified software, and an interview to a tutor of one of the
used MOOCs performed at the end of this research. Based on the answers obtained to the questions regarding the gamification software in the final questionnaire, we could group the results obtained from each of the courses, which we present below. On a five-point Likert scale, where 1 means "terrible" and 5 "excellent", half of the participants considered to have a good / very good user experience with the applied gamification software. Also, it's relevant to state that neither of the repliers stated to have a negative experience which is an important point to highlight. Also, in general, half of the respondents stated that the gamification software had a positive impact on their motivation, interest, ability to acquire new knowledge and on the course final grade. The remaining half felt that the software had an indifferent impact on these last points. These results may be a positive indication that this software produced motivation and captivated learners' interest.

Lastly, when asked if they agree to extend the gamification software to all other users of the MOOC Técnico platform the majority of learners (60%) consider it a good idea, while the remaining 40% admitted being indifferent to this idea. This discrepancy in rates demonstrates, once again, the relevance attributed by learners, who enrolled in these online courses, to this software. This division of opinions among learners was already expected. As in games, there are several types of players, in learning, there are also different types of learners who, because they have different opinions, motivations or beliefs, naturally have different ways to feel engaged. Even though the positive feedback has not been reflected in an increase in the number and variety of activities (events) carried out in MOOCs, it is in itself a strong starting point that possibly still needs to be further studied and developed.

Another metric that was also taken into account to assess the utility of this artefact was an interview conducted with one of the tutors responsible for the online droneX course used in this research, Prof. Alexandra Moutinho. Bellow we present some important comments advanced by the professor. Regarding the low participation of learners in the discussion forum of the droneX course, Prof. Alexandra says that this is not a recent situation and that it has been happening in recent years. In particular, in this edition, the situation has deteriorated a little more. The professor states that students are tired, and so it's expected they start reducing the number of optional activities they perform. When asked if she intended to use the gamification software again since the results obtained in this research were not fully achieved. To this last question, Prof. Alexandra said that yes, she intends to use the software again soon, in particular, to support a curricular course in IST.

The previously obtained results indicate that the utility of the produced artefact was, in general, successfully obtained. Some of the participants who had access to the gamification software consider that it helped them in various personal ways. We also have a positive from Prof. Alexandra, that considers using the software again in future courses editions. In general, this demonstrates that those involved in this experience consider the use of this software relevant, thus validating the quality of the artefact in practical use.

**CONCLUSION**

**Contributions and Limitations**

With this research, we were able to verify the usual difficulties felt when applying gamification techniques on an online MOOC platform with the purpose of increasing learners' involvement. Also, this gamification software proved to have some value for some of the users of the MOOC Técnico platform. Although, until now, there is no concrete evidence of improved engagement, the course tutors are willing and receptive to continue using the Gamma Técnico software, so it will continue to be applied to online courses on this platform.

As a limitation of this research, we can highlight the fact that there are different profiles of learners, who feel engaged in different ways, making it difficult to find elements that transversally capture all profiles. We also have reasons to believe that the COVID-19 pandemic had a negative impact significant on the proactiveness of the participants and that, subsequently, prevented the achievement of more optimistic levels of engagement.

**Future Work**

For future work we consider relevant extend the use of Gamma Técnico to more online courses running on the MOOC Técnico platform.

**REFERENCES**


