Designing and Executing a Gamified Hands-On MOOC for Technology Enthusiasts

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MOOCs have received much attention due to their openness, scale, reach and have challenged the roles, structure and models of higher education. Several challenges have emerged, such as retention rates, content delivery, and assessment. Techniques like gamification and its focus on motivational aspects might alleviate the retention problem, while technology enables massive content delivery and real time assessment. This paper discusses the ideas and motivation behind the choices made while designing, implementing, executing and analyzing the results of a MOOC for technology enthusiasts, titled "Introduction to Raspberry Pi". Two track options were defined in order to accommodate different student types. Some of the main challenges faced were: accommodating different ages, skill levels and backgrounds, how to assess hardware projects, and trying to keep students motivated. By the end of the course, there were amazing international collaboration projects and interesting user feedback and the total retention rate was 18.5%. Final recommendations and afterthoughts are expressed in order to enhance future MOOCs.

Keywords—MOOC; gamification; real time assessment; student retention;

I. Introduction

The MOOC described in this paper, titled "Introduction to Raspberry Pi", was offered as a series of tutorials on the basic concepts required to start building applications with the Raspberry Pi computer. Such basic concepts include installation and configuration of operating systems, computer programming, and hardware for input/output interaction. The course was conducted by three instructors, namely, the authors.

This MOOC was targeted to a Spanish speaking audience, and thus it was only offered in Spanish. It was thought that way because Spanish is our native language and there were no other Raspberry Pi MOOCs offered in the language. Additionally, it served the purpose of delivering such knowledge to students with low English fluency, who would otherwise not enroll or properly comprehend the material [6].

Among the initial motivators for creating this course, we wanted not only to encourage people's interest in technology, but also to give them a hands-on experience and working knowledge. In addition, we were interested in experimenting with e-learning technologies, mainly, cloud services, massive distributed content delivery, gamification, real time assessment tools, and social learning techniques, expecting to enhance the university's reputation by connecting with students and showcasing our faculty and courses.

We chose the Raspberry Pi, which is a very popular credit card sized, easily accessible, $35 microcomputer with I/O ports available for controlling external hardware, with a growing community and rich documentation [1], characteristics that generated much interest and curiosity about this platform.

Since one of the main objectives of this course was teaching students from multiple backgrounds how to implement easy projects with the Raspberry Pi, we made sure students had the basic programming background needed by including an introductory section on the Python programming language, following the Raspberry Pi Foundation's recommendation on using it for learning [2].

II. Announcing the Course

The MOOC was directed to a wide variety of students with an interest in learning the basics about computers, programming, hardware, and the Raspberry Pi itself, but was open to any student regardless of their background.

The team behind this MOOC was very small, namely the instructors, and to a minor extent the university's e-learning team. This gave us great flexibility in decision making and opportunities for implementation, but it also led to great responsibility and effort on behalf of the instructors. Additionally, a very low budget was assigned for the project, which meant we had to be creative in how to approach the challenges.

Multiple methods were used for promoting the course, starting from the most successful: The instructors targeted specialized forums and websites, including the Raspberry Pi official website, where the course was announced in their landing page. Word of mouth also played an important role since more than 30 emails, 400 tweets and over 1,500 Facebook shares were issued from the official MOOC website. The instructors also had interviews at local radio stations, and a small note on the newspaper was published.

Regarding online paid advertising, we tried Google Ads, but due to long delays and the fact that we do not own the Raspberry Pi trademark, our request to advertise was denied. In contrast, Facebook Ads were much less troublesome and the whole process took about 24 hours.

These announcements were distributed during September 2013, allowing more than one month for enrollment. By the end of October, the promotional video had been watched over 10,000 times.

III. STRUCTURE OF THE COURSE

Since this was an introductory course, no specific knowledge was required. Besides, the Raspberry Pi was launched less than two years earlier, making it a relatively new technology, so the background of our students could be very diverse, ranging from total beginners to experts in multiple fields. Taking this into account, the course was built into discrete, very specific learning objects where the expert could simply skip those pieces of knowledge already mastered.

Weekly Agenda

The structure used was traditional: Lecture videos focused on theory, hands-on videos focused on practice, quizzes evaluating mostly theoretical knowledge and labs evaluating practical knowledge. The course was offered in four weeks, with several didactical units about one specific general topic each week.

Alí Lemus conducted the first week's material, which addressed "What is the Raspberry Pi?", "What can be done with it" and "Installation and Configuration". The lectures mentioned basic computer principles such as Operating Systems for beginners interspersed with specific Raspberry Pi details for advanced students. We started by giving theoretical lectures to grasp important concepts, then practical how-to so they were able to see how it is done, followed by quizzes evaluating theoretical comprehension of the material, and labs where they could implemented the how-to videos and expanded that knowledge on their own.

The second week, by Andrea Quan, was an introductory Computer Programming section divided into three parts. From our experience teaching and studying about programming, and based on several books and basic programming courses and MOOCS, such as [4], we came up with the topics that cover the basic concepts needed for learning computer programming in an easy way. Lectures consisted on a brief and concise description of the section concepts followed by a live demonstration of how to apply them in Python.

The third week covered the Hardware and GPIO section, by Eduardo Corpeño, where most of the lectures consisted of an introduction to a particular digital control hardware technique, followed by a detailed programming example, and a live demonstration video. The theoretical material was developed by means of a slideshow presentation with digital pen annotations and narrated audio. The live demonstration videos show a digital general purpose board interacting with the Raspberry Pi. All of these elements were compiled into a single video per unit.

The fourth week was conducted again by Alí Lemus, and its main objective was to encourage students to form long lasting communities, both online and offline, where they could deepen their knowledge on the platform, develop and share applications, and work together.

Quizzes

At the end of each unit, the students were required to take a quiz based on the content of the videos they had recently watched. These quizzes were implemented in the form of a multiple choice assessment, because they allow real-time computer assessment, without human supervision for grading, which, according to [10] has a higher perceived reliability.

Each quiz displayed a limited number of randomly selected questions, which came from a larger set (e.g. 10 questions displayed, out of 25 available). Similarly, each question had more options for answers, either correct or incorrect, than the ones actually displayed by random selection (e.g. 4 options displayed, at least one of which is strictly correct, out of 10 available).

Laboratories

A document containing an explanation of the work expected from the students for each of the hands-on Laboratory exercises and the rules of the ensuing assessment was always provided.

Creative assessment techniques capable of verifying the correctness of software installation, programming exercises, and external hardware control, were carefully planned and executed. After extensive discussion, multiple choice assessments were agreed upon for the same reasons as for quizzes.

Since hands-on labs require the student to perform a task, the lab assessments ask about the process or results of performing such task. For instance, a question about a blinking LED example might ask how many times in a second the LED actually blinks, with special care not to show ambiguous choices.

Gamification

Gamification and Fun Theory strategies were embedded into the structure of the MOOC in order to enhance student motivation. Three of these strategies deserve special mention: The double-track scheme for managing different student types described below; an automatic classification of students into leagues according to their accumulated grades; and a repeated-attempt policy for quizzes and labs.

As for the league classifier, students were sorted inside four leagues, each of which had one fourth of the students at all times. An online leaderboard was always shown, allowing the students to know their relative rank and progress over time. The purpose behind the leagues was to avoid the negative effects of leaderboards [11]. Inside their league students would perform better than on a general leaderboard, motivating them to improve. Being an indicator on their knowledge and commitment with the MOOC, leagues also helped while forming groups for the final project.

Fig. 1: As part of the gamification process, four leagues were created in order to classify students' grades and commitment.

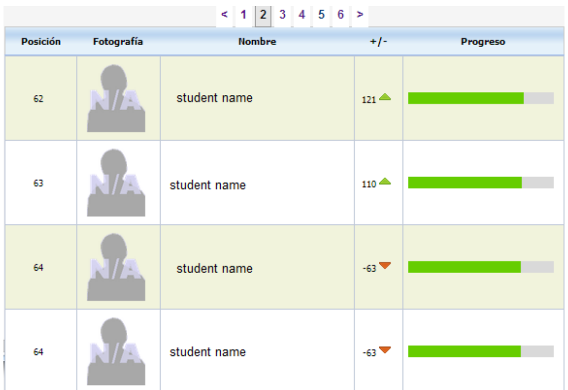

Fig. 2: Inside each league there was a leaderboard with a progress bar and how many positions the student has gained/lost.

The repeated-attempt policy for quizzes and labs consisted in allowing the student to make up to 5 attempts on every quiz and lab, with a 4-hour cool down delay between attempts, and a time limit for each attempt. The objective of allowing multiple attempts was to promote mastery, whereas the cool down delay and attempt limit were enforced to avoid brute force attempts and to motivate insightful thinking.

These methodologies were purposefully selected, expecting to reach higher than average student motivation and retention. The successfully high retention actually achieved in this course lead us to encourage other MOOC developers to incorporate gamification and fun theory techniques into their courses.

IV. Building the Course

For the entire development of the course we used the Galileo Educational System (GES), based on the .LRN/ OpenACS LMS, which includes a variety of e-learning tools, such as, forums, quizzes and content delivery. This was managed by the GES Team, lessening the instructor's workload.

Apart from the GES, other cloud services were embedded into the platform. YouTube was chosen over other platforms in order to host videos, the main reasons being price, analytics, uptime, and users being used to its interface and trusting its service. OSQA forums were used to provide massive communication with students.

Despite its massive nature, talking directly to the camera gives the students and the instructors the impression of a one on one communication and is perceived as more educational [13]. Hands-on demos are also beneficial because the students are able to follow the instructions as they are being executed, and may replay in case they miss something.

We used our personal computers to produce the entire content of the course. Videos were recorded using standard webcams, a conventional recording digital camera and mobile phone cameras. The screen capture software employed is Camtasia Studio, which proved simple, yet powerful enough for our needs.

Most videos were recorded, edited and produced by the instructors. Early on we noticed the A/V team had little knowledge on the specific subject, taking more time to explain how and where to edit the videos than to do it ourselves. Besides, according to [3], professionally produced video versus homemade videos have little impact on students.

In the end, 58 videos with an appropriate [12] average length of 9 minutes were recorded, totaling over 9 hours of video. 108 quiz questions, with over 485 possible answers were distributed among seven quizzes. Seven hands on labs, one final project and various complimentary files were produced.

The total workload spent by the staff was more than 470 hours, distributed as follows: Instructors worked an approximate total of 80 hours to produce video content, 35 hours producing quizzes and labs, 100 hours preparing the lectures and demos, 60 hours at the forums and 100 hours of post-production, which included final project assessment, grading and certificate generation. The development and support group from the GES spent approximately 100 hours in preparing and enabling the course infrastructure, and platform support.

V. Launching the Course

The course launched on October 14th, 2013, with 2,927 registered students. The top 5 countries which watched the first video according to YouTube analytics demographics were: Spain (38%), Guatemala (18%), Mexico (11%), Colombia (8.8%) and Argentina (3.4%).

Two tracks: "Light" and "Advanced" were offered for passive and active participants respectively, since those types have the highest probability of finishing the course [9][14]. In comparison with a traditional double track course, students were not required to select a track and commit to it. Instead, the track was determined by their final grade.

Out of the 200 total points, tracks were awarded as follows: the light track was awarded to students who obtained 60 points or more, and the advanced track to those who obtained 120 points or more. Quizzes, which were mainly theoretical, accounted for 100 points, being the only intended requirement for the light track. Labs and projects, which were mainly practical, represented the remaining 100 points and were necessary to complete the advanced track.

Immediately after launching the course, a thread was provided by the instructors for students to introduce themselves and disclose their background. Following are excerpts of translated introductions in said thread.

- "I'm a medicine doctor from Catalunya... addicted to Linux..."
- "I'm 16 years old... I'd like to make a home automation project..."
- "I'd like to learn about programming and robotics..."
- "Due to family matters I don't have much free time, but this course suits me..."
- "I'm an Italian economist engineer. I understand Spanish but don't speak it..."

This thread, with 154 answers and 1,180 views, showed the cultural and background diversity amongst the participants, as well as their enthusiasm and willingness to participate and collaborate throughout the course. This was a very vibrant thread full of positive energy and goodwill.

Communication and Monitoring

Forums were the preferred communication method. They allowed many-to-many conversations and students were encouraged to ask questions and to comment and answer as they saw fit. One-way email notifications were used for communicating content, technical errors, hints, announcements or other one-to-many information. Emails and phone calls from students were greatly discouraged and generally ignored.

The students used the forum mostly to post questions and answers about the subjects being taught, to report errors in the videos and other material, and by the end of the course, to show their gratitude and request a future advanced course on the Raspberry Pi.

The instructors monitored the course on a daily basis during their assigned week, and at least three days a week otherwise. This participation was considered a priority since discussion forums and the instructor's role are illustrated in [8] amongst the most relevant factors in student motivation.

There were some official activities managed in the forums, for example, at the end of the Hardware and GPIO section, students were invited to post videos showing their implementation of an optional project. Although no credit was awarded for this, 42 projects were posted, many of which were made in groups.

At the beginning of each week, the respective instructor sent an email notification to the students, explaining the content that would be covered during the week, and creating excitement about the upcoming assignments and challenges.

VI. Wrapping up the Course

Out of the total 2,927 enrolled students, 542 completed the course successfully, which is a 18.52% retention, or, disregarding 1,985 no-show students, a 57.54% retention. Either way, the retention achieved in this course is much higher than the 6.5% average reported in [7].

The light track was completed by 265 students, with an average final score of 91 points (the pass mark was 60), while 278 students completed the advanced track, with an average final score of 155 (the pass mark being 120).

Fifty final projects were presented by approximately 90 students. These were in the most part products of international collaboration between students that met in this course. Interestingly, there were various groups which included parent-and-child as part of the team. Thanks to the forums, we found out these were Tech oriented parents sharing their passion with their children. In general, the complexity, creativity, and technical level achieved in the projects were very high.

VII. Analyzing the Data

While working on this paper we regretted not conducting a student survey, as it hindered our data analysis. For such reason, we encourage MOOC developers to conduct standardized surveys as discussed in [5].

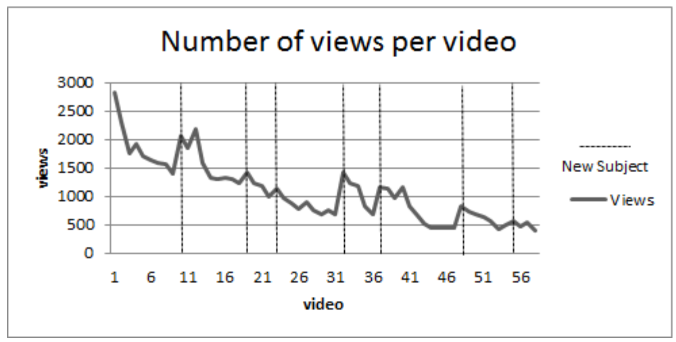

Fig. 3: Amount of views per video throughout the course.

Fig.3 Shows two interesting things: First, the dropout rate; Second, that every time there was a change of subject (dotted vertical lines), the amount of views increased.

Also, harder to see is that videos that contained hands-on practical lectures generally had more viewers with higher retention rates.

Fig. 4: Average absolute audience retention.

Fig. 5: Average relative audience retention.

Average absolute audience retention rates were 62% for all videos, Fig.4 shows a typical graph. Relative retention rates as compared to the rest of videos hosted on YouTube were usually above average except for the final credits section where retention fell off dramatically as can be seen in Fig. 5.

In the forums, a total 196 unique users posted 369 threads, getting 1,524 answers.

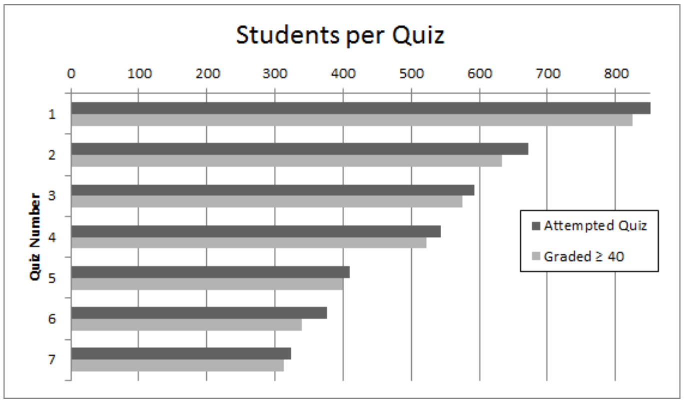

Fig. 6: The absolute number of students who attempted each quiz compared to the number of students who obtained a grade of at least 40 points.

We obtained a mode of 100 points in every quiz, with an average of 1.52 attempts per quiz. This situation suggests that the repeated-attempt policy motivates students to aim for a grade of 100 whenever possible.

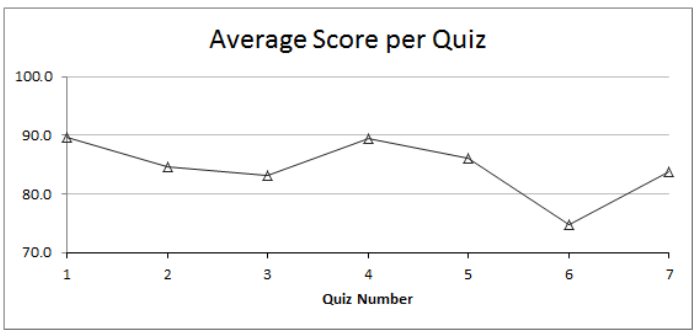

Fig. 7: The average scores per quiz shows a tendency of the students to obtain good grades in all unit quizzes in spite of the ever present dropout rate throughout the length of the course.

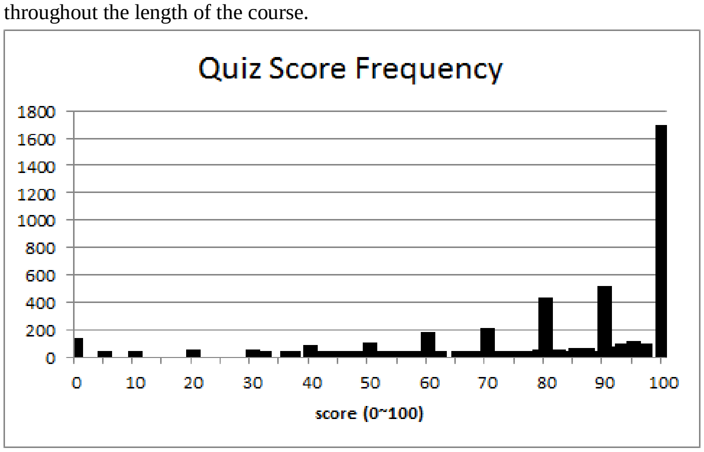

Fig. 8: Quiz score distribution: We believe the ability to retake quizzes helped students try to achieve mastery and get the perfect score, as can be noted by having much more perfect scores than any other score.

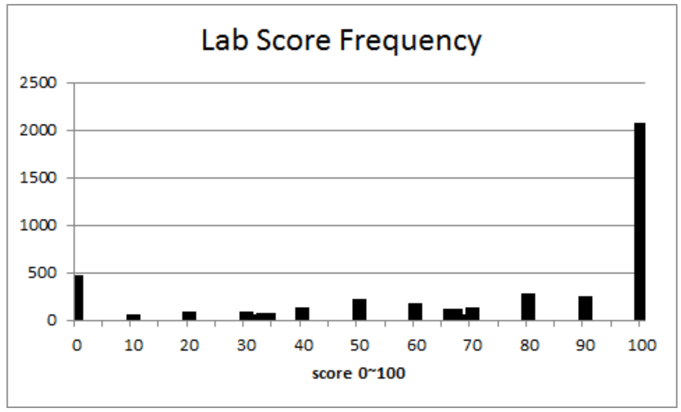

Fig. 9: Lab score frequency: In labs, the frequency distribution is even more discrete, where it seems students that do the hands-on labs do them all the way from start to finish.

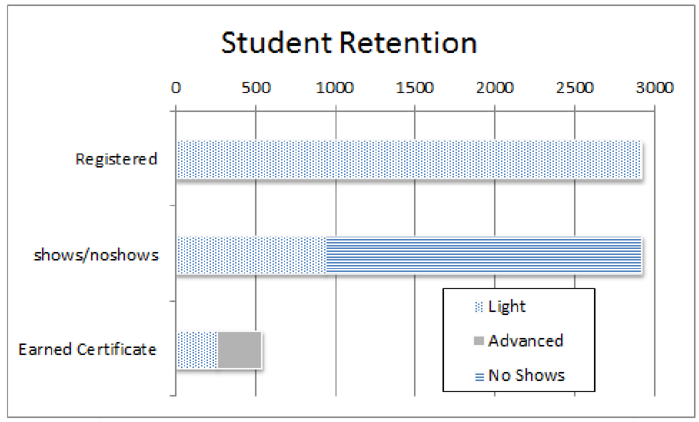

Fig. 10: Of the 2,927 students who registered, 1,985 were “no shows”. Of the 942 students who started the course, 543 obtained a certificate.

Factors promoting student completion and motivation are hinted in the data shown above. While some of the most common barriers expressed by the students in forums were lack of time and lack of hardware.

VIII. Other Findings

Information on retrieval and duration of access to learning objects such as videos is a clear indicator of student engagement. Thorough analytics proved to be an invaluable research tool.

Forums provide a vast amount of information in various forms, including: formative assessment, content and technical errors, student motivations and interests, and suggestions.

Although teaching assistants were not used in this course, we concluded that the instructor workload resulted excessive, and that teaching assistant support is necessary for MOOCs. Teaching assistants could help with video editing, assessment, and should participate in the discussion forums regularly.

Additional staff is also required for production of educational material and website management.

Audio and video quality should meet a certain minimum standard and preferably have subtitles. Some of our published videos had very low quality audio and retention rates in those specific videos were under average.

In case there are required or optional materials, it is recommended that a complete list is given prior to starting the course and to be very explicit in which are the optional and required materials so the students can prepare appropriately.

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