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Design, Implementation and Evaluation of SPOCs at the Universidad Carlos III de Madrid

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Abstract: The Universidad Carlos III de Madrid has been offering several face-to-face remedial courses for new students to review or learn concepts and practical skills that they should know before starting their degree program. During 2012 and 2013, our University adopted MOOC-like technologies to support some of these courses so that a blended learning methodology could be applied in a particular educational context, i.e. by using SPOCs (Small Private Online Courses). This paper gathers a list of issues, challenges and solutions when implementing these SPOCs. Based on these challenges and issues, a design process is proposed for the implementation of SPOCs. In addition, an evaluation is presented of the different use of the offered courses based on indicators such as the number of videos accessed, number of exercises accessed, number of videos completed, number of exercises correctly solved or time spent on the platform.

Keywords: MOOCs, SPOCs, learning platforms, learning experiences, remedial education, evaluation

1 Introduction

After the New York Times declared 2012 "the year of the MOOC" Massive Open Online Course's (MOOCs) popularity has increased. According to [Siemens, 2013] MOOCs are massive (large scale of students), open (in terms of access), online (exclusively), courses (having start and stop dates).

The MOOC philosophy is changing the way of teaching, as predicted by [Martin, 2012], and there is a need for analysis of the pedagogies that might be more suitable for these environments in different situations. Pedagogical foundations for MOOCs have already been established [Glance, 2013]. In addition, there is a question of the most suitable platforms to use in these contexts.

MOOCs have three key characteristics according to [Kennedy, 2014]: "varied definitions of openness, barriers to persistence, and a distinct structure that takes the form as one of two pedagogical approaches." MOOCs are, then, generally classified as cMOOCs or xMOOCs. The two categories involve two very different pedagogical approaches: cMOOCs are based on a connectivist approach in which the knowledge is based on social interactions, and xMOOCs are based on a more traditional course approach and structure.

Regarding the platforms, according to [Kay, 2013], LMSs do not have as many differences as new MOOC platforms, but the platforms should evolve to better suit the needs of MOOCs, e.g. increase the learning analytics support, the gamification features, or the adaptive support. Approaches of adaptation such as the one presented in [Muñoz-Organero, 2010] can be incorporated in MOOCs, or competitive systems such as the one described in [Muñoz-Merino, 2012] might be integrated to promote engagement.

Small Private Online Courses (SPOCs) [Fox, 2013] [Goral, 2013] emerged as an opportunity to use MOOC philosophy for private courses with a reduced number of students. A lot of benefits can be obtained with the incorporation of MOOC technologies in these environments.

Remedial courses (so-called zero-level courses – "cursos 0" in Spanish) are basic courses that several universities teach on a regular basis before a degree starts, to ensure that all students have a common base in disciplines such as Mathematics, Physics, Chemistry, or Biology. These courses are not sensu stricto degree courses but "extra" university short courses. They are often considered expensive in time and resources for the academic organizations. The Universidad Carlos III de Madrid (UC3M) introduced MOOC-like technologies for small and controlled groups of students (between 100 and 300 for each course) and in a private environment (our educational intranet), so these remedial courses were the perfect context in which to implement so-called SPOCs,

The SPOCs implemented at Universidad Carlos III de Madrid aimed to solve a problem with zero-level courses. Such couirses were usually offered for only one week at the beginning of September. Many students need more time to review the different concepts covered. The SPOCs offer students the possibility of working longer with the topics of the course and tthe provision of additional resources. Moreover, the SPOCs enable the possibility of making the face-to-face class sessions more productive as students can watch videos and solve several exercises out of face-to-face time.

We are going to describe here how the Universidad Carlos III de Madrid (UC3M) improved traditional on-campus remedial courses through MOOC-like technology, using our own adapted instance of the Khan Academy (KA) platform [Khan Academy, 2012-013]. We report on difficulties and solutions as well as analysing the results. The main contributions of this paper are the following:

1) Explanation of the difficulties and issues when implementing SPOCs at UC3M and the decisions taken to solve them. Although there are other

papers that explain the implementation of MOOC technology, they do not go into details about the difficulties or the methods that they use to overcome those difficulties.

2) Presentation of a design process for the implementation of MOOCs and SPOCs based on this experience, which can be extended in other similar contexts.
3) Comparison of the activity use of these SPOCs with those reported in previous work about MOOCs. Dropout rates are high in MOOCs, this being one of their main problems, as most MOOCs have a dropout rate higher than 85% [Onah, 2014]. There is no agreement on how to measure the dropout rate and different work measures it in different ways but one common way is to measure it as the number of students that do not earn a certificate. Dropout rates are high in MOOCs but the SPOC context is different so the activity might change in SPOC contexts. Moreover, MOOC dropout rates are usually used as a metric of success. But in a SPOC, like the one presented here, the concept of success is different as students might not need and are not expected to explore all the content but just the things they need
4) Comparison of the activity in a SPOC depending on the type of course: maths, physics and chemistry. Recently, the effect of the topic has been analysed in discussion forums about MOOCs [Wang, 2016].
5) Comparison of the activity use with the MOOC technology before, after and during the face to face sessions. MOOC activity reported previously does not nclude or explain this division as they do not have face to face sessions (as in this SPOC experience).

2 Related Work

Several researchers have pointed to the advantages of MOOCS such as the potential to extend education to everybody or the self-directed learning methodology [Nicorama, 2013]. However, several drawbacks have been cited including such as the high dropout rates, sustainability, cheating or plagiarism [Siemens, 2013]. A recent review has identified several concerns about MOOCs including their lack of evidence and the unrealistic expectations [Sinclair, 2015].

There are many MOOC platforms to support this new paradigm, each with different functionality, e.g. even for video playing, and a comparison of their main features is in [Kay, 2013]. Standard Learning Management Systems (LMSs) platforms might also be used for the MOOC paradigm and so the differences with the MOOC platforms are not always clear [Kay, 2013]. Therefore, the selection of the proper platforms for a specific educational setting is a challenge when using MOOC technology.

Another challenge is to provide authoring support for teachers in the process of creatiing course resources [Kay, 2013]. In addition, important aspects that are emerging in MOOCs are the application of gamification techniques and serious games, which might increase students' motivation and reduce dropout rates (e.g. a recent example of integration of serious games in edX is in [Freire, 2014], or the use of learning analytics to obtain information of the learning process on a large scale (e.g. [Kop, 2011] presents the importance of learning analytics in MOOC environments).

In our context, the report of experiences with MOOC technology is important in order to know how in these experiences, the authors addressed the different design and implementation challenges (e.g. selection of platforms, the configuration of the authoring process or the use of gamification) and to evaluate them in terms e.g. of dropout rates. In this work, we comment on all of these aspects for a specific case study of the use of SPOCs for remedial education.

The concept of SPOCs emerged as a way to use MOOC technology for private courses [Fox, 2013] [Goral, 2013] The SPOCs have a set of differences with respect to MOOCs as presented qualitatively [Delgado Kloos, 2014]. The SPOCs can be combined with different pedagogies such as the flipped classroom [Delgado Kloos, 2015; Chengjie, 2015]. MOOC technology has been adapted to SPOCs for such as encouraging interaction [Hardt, 2016].

There have also already been different reports about MOOC and SPOC experiences. [Osvaldo Rodríguez, 2013] reports on two very different MOOCs at the University of Stanford with very different dropout rates (40% in the c-MOOC and 85% in the x-MOOC). The first MOOC in the edX platform about "Circuits and Electronics" has also been analyzed giving details about the use of resources by students and their time spent on them [Breslow, 2013]. Another report on the dropout rate of a MIT MOOC is in [Kay, 2013] as 95%. While there are other works that report dropout rates around 81% [Aboshady, 2015], a recent review of around 50 MOOCs showed dropout rates that were usually greater than 90% [Khalil, 2014]. There are also some experiences with SPOCs instead of MOOCs such as [Combefis, 2014] where the dropout rate is not given but there is an analysis based on a survey. of the student workload related to the exercises.

3 Context of the KA-UC3M Experience

At the Universidad Carlos III de Madrid (UC3M), the first selected zero-level courses to be presented as SPOCs were Physics in summer 2012 with Mathematics, Physics, and Chemistry following in summer 2013. Table 1 gives an overview of the number of students enrolled, teachers participating, exercises and videos for each of the SPOCs and years.

The total number of videos in each course was quite similar, ranging from 22 to 30. There was a specific video for each atomic topic, so the difference depends on the different number of topics for each course. Teachers had to create at least one exercise related to each video. There were some topics that required more than one exercise, especially in Chemistry, so the number of exercises was increased for this course.

Traditionally, new students who enrolled in the remedial courses received lessons on campus. These lessons ran for one week and took place at the beginning of September. The main problems with this model were the limited amount of time to study all the concepts, and a very compressed high-demand schedule.

Course	# Students	# Teachers	# Exercises	#Videos
Summer 2012 Physics	102	6	35	27
Summer 2013 Physics	181	10	30	30
Mathematics	278	16	30	25
Chemical	91	7	49	22

Table 1: Number of students, teachers, exercises, and videos, in the SPOC experience, by course and year

With the introduction of Khan Academy (KA) technology, we planned a blended learning methodology. Students could access the different resources prepared by teachers during the month of August anytime and anywhere. Students could watch videos, solve exercises or interact with other classmates before the face to face lessons. The lessons take place during the first week of September, and students can take more advantage of these class sessions as they already know the concepts that they studied in August within our particular KA implementation (KA-UC3M). Therefore, students could focus and ask the teachers about more advanced topics. In addition, students could devote more time to study the different topics as the educational resources were available in the platform for the time they were enrolled. This is a feature of flipped classroom. It got positive feedback from students [Sharp, 2016] who also prefer the flipped classrooms over traditional classrooms [Gilboy, 2015].

4 Implementation

In the process of the creation, deployment, and evaluation of MOOC-like technologies to improve our remedial courses, different issues and challenges emerged. This section describes issues, decisions taken and lessons learned through the implementation of our private Khan Academy (KA-UC3M) installation, first in 2012 and in an improved implementation in 2013. In addition, a formalization of the design process for the implementation of SPOCs is provided based on our experience.

Based on the experience in 2012, UC3M created the Educational Technology and Teaching Innovation Unit [UTEID, 2013]. Its purpose is to help in the development of MOOC technology and in the creation of educational resources. The existence of this UTEID technical unit made the process easier and more scalable in 2013.

The main educational requirements considered to MOOCify zero courses were the possibilities of watching videos; solving automatic exercises; the provision of useful analytics of the learning process to evaluate the course; making a clear structure of the content; automatically available help for students when solving exercises if they get stuck, and improved communication among students. The requirements for help when solving exercises and the communication among students were stronger than in other typical MOOCs because these SPOCs run in August, the vacation month in Spain. Therefore, UC3M did not plan that teachers would give any support during the students' interaction, so the platform has to provide mechanisms to overcome this..

4.1 Selection of the Supporting platform

There are quite a few different platforms for supporting MOOCs. Each platform has a specific set of features. The platform should be selected depending on the educational context requirements and the learning outcomes to be achieved.

At the time (spring 2012), we did not find a platform that fulfilled all the previously commented main requirements. We decided to use a combination of two platforms: Khan Academy and Moodle. The KA platform enabled watching videos, solving exercises, generating relevant hints for exercises, and providing useful analytics data about the learning process. The Moodle LMS mainly enabled communication between students.

Although watching videos and solving exercises can also be done in Moodle, the KA system provides a more powerful learning analytics module. The exercises and videos have to be related to the KA platform to enable this learning analytics support. In addition, the KA exercise framework adapted better to our purposes.

Although the KA platform provides some communication features (e.g. the possibility of inserting comments for each video), we required other features which are present in Moodle but not in the KA platform. These were the possibility of creating common forums where all the participants can contribute, and enabling direct private messages among participants.

Moodle but also the KA platform provided the content structure. Moodle divided the content by sections, subsections, and chapters. Each chapter usually had a related video and an exercise. The KA platform presented the content using an index and a knowledge map that was enabled so that students could go through the different exercises and see their different connections. The combination of both platforms enables different navigational paths. Users know Moodle better and it is also the default Learning Management System for all degrees at UC3M. Therefore, students would probably be more familiar with Moodle's content and navigational structure, and its interface would be better for usability purposes.

There were also some features of the KA platform which were used in the SPOCs, but that were not key requirements. Among these features are the possibility of configuring an avatar, the possibility of setting and tracking goals, and the use of a recommender for subsequent exercises. On the other hand, many different features of Moodle which were not used could be enabled in the future for enhanced experiences. Some examples are the assignment, the wiki and the glossary.

The KA platform was connected with Moodle. Some aspects integrated with this solution were single sign-on and the Moodle grade-book connection with the KA user interactions. Moodle enables administrators to set the teachers and students for each course, while the KA platform needs students to select their coaches, which is a similar role to a teacher. The single sign-on enables a user logged into one platform to enter into the other, but also converts teachers in Moodle to coaches of all their students in the KA platform.

An important difference between Moodle and the KA platform is that Moodle is designed for private courses in which only a predefined number of enrolled students are allowed to enter and interact with the course materials (so only a registered student can access some courses), while the KA platform enables access to all videos and exercises for any students registered to any course. This was an issue in 2013 as there were three different courses with different students enrolled in each one (students might belong to one, two or all of the courses). The solution adopted was to have one Moodle instance but three instances of the KA platform (one for each course).

In addition, Moodle was the initial platform for entry into the course, and Moodle had external links to the KA resources.

Although an initial concern was that students might get confused with two different interfaces from two different platforms, this did not present a problem for students. In any case, we adapted some links in 2013 to simplify going from one platform to another.

4.2 Authoring videos

The creation of videos posed two main challenges: 1) Find the proper methodologies and good practices to maximize students' learning. 2) Give homogeneous videos to students so that they perceive the same general rules, such as e.g. the inclusion of university logos in the same way. To achieve this, a style document for the creation of videos must be available to teachers.

In 2012, teachers only received a few general rules about the process of video creation (e.g. about the recommended duration). People from the UTEID technical unit reviewed all videos from 2012. Based on these reviews, teachers received more specific rules in the 2013 style-guide. Some rules were related to e.g. the combination of colors, or the applications to use for generating videos. Nevertheless, teachers had enough freedom to adapt their videos to their personal teaching style.

Another issue was how to provide resources to create the videos. Teachers were able to create videos on their own, but UC3M enabled a place for creating videos in the library with all the necessary resources and with the support of the UTEID experts. A final issue was how to deal with the process of receiving the videos, publishing them in the YouTube platform, and annotating them with meaningful tags. The UTEID created a tool to manage this process of uploading videos and annotate them. The tool could also receive videos selected by courses.

4.3 Authoring exercises

One of the main problems with generating exercises was that teachers were not able to create them directly using the KA format, which is an HTML one with specific tags. Many teachers feel it is quite difficult to create the exercises directly in this format. During the first year (Physics course, summer 2012) this issue was tackled by creating a set of MS Word file templates for the different types of exercises considered: fill in the blank, multiple choice and checkbox. Teachers had to fill in the corresponding content and send these files to two experts who did the final conversion to the KA framework.

In summer 2013, as the number of courses and teachers was considerable, it was not feasible to follow the previous strategy: the experts would have had to format too many exercises. We required a scalable solution. Moreover, with the previous solution teachers were not able to see how the exercises run directly in the platform: they only had access to the MS Word files. We designed and implemented an authoring tool to mitigate these issues. This tool enabled teachers to create exercises through a simple Web interface. The type of exercises that the authoring tool enabled was “fill in the blank” with the possibility of establishing parametric variables. Each time that a student accessed an exercise, the parametric variables had a different random value within a range until the student answered correctly. Furthermore, the tool enabled formatting the text with an HTML editor, to calculate formulae for the solution or adding hints. In addition, teachers could view the exercise being done on the KA platform during their exercise design. With this solution, experts did not have to format all the exercises because the authoring tool translated them automatically into the corresponding format. Nevertheless, there were some specific exercises that the authoring tool was not able to create (e.g. restrictions among variables). Experts had to do the formatting for these exercises.

Based on the first SPOC for Physics, during summer 2012, we learned other lessons: for example we realized that multiple choice exercises with long texts as options presented problems with visualisation, because long texts as options had to be in a narrow column on the right. For this reason, in 2013, the preferred type of exercises was fill-in-the-blank. Multiple choice exercises were only used in cases where fill-in-the-blank exercises did not make sense, with limits on the length of the possible options.

The authoring tool works without registration and anyone with Web access can log into it to create exercises. This tool was integrated into the video authoring tool created by the UTEID. In this way, the creation of exercises is restricted to the teachers of the course, and exercises are grouped by the different courses. An important aspect to note is that teachers create videos and exercises and upload the created resources to the servers using the authoring tools, but the educational resources are not automatically uploaded to the platforms. Instead experts are needed to do this task. To do this final step, experts need to know the knowledge structure of the course and which exercises are related to which videos. This is given to the experts by the teachers.

4.4 Gamification

Although gamification was not one of the initial main requirements, the KA platform brought in this important feature. Gamification might motivate and encourage students to learn more and better by earning points and badges during the learning process [Li, 2013]. The KA platform provides a set of five different types of badges by default (meteorites, moon, earth, black hole and challenge patches). Each type of badge is identified by a different image. We adapted these badges to the context of the Universidad Carlos III de Madrid. We replaced the initial images by five different names and images of Madrid monuments from the times of King Carlos III. The highest achievement badges (previously the challenge badges) represented one of the buildings in our own university.

The KA platform can give badges for mastering different topics. A student must achieve proficiency in a topic in order to master it. As we personalized the contents of the KA platform, the conditions for achieving badges related to topics had to be redefined. We defined three different levels of content: section, sub-section, and chapter. Students who achieved proficiency in all chapters of a sub-section received one type of badge, while students who achieved proficiency in all sub-sections of a section received another type of badge. Teachers of each course had to fill in a form with the structure in the three levels of hierarchy so the badges could be awarded in this way. The number of badges for each course was different as there were a different number of sections and sub-sections in each one.

Moreover, some of the KA badges not related to achieving proficiency in exercises had to be removed, because they did not make sense in our context. Others had to be adapted (e.g. badges for watching videos for some amount of time because the total number of minutes for watching videos was quite different from the original KA educational materials). These adaptations were made in the 2013 KA-UC3M remedial courses, based on observations from the 2012 experience.

4.5 Learning analytics

One important functionality provided by KA is its learning analytics support. The platform generates many reports about students' interactions, students' performance, results divided by topics, etc. For example, teachers can easily see the number of students that struggle in an exercise or obtain the proficiency, and students can see the time spent on different topics, classified by videos and exercises. This type of information helps students and teachers to understand the learning process, evaluate it and try to improve it. This is particularly important when there are many students in the platform, which is the case even for a small course.

The learning analytics process has a set of phases [Clow, 2012]. Collecting the data from students' interactions is done in a very detailed way in the KA platform. This data is stored in different tables within the Data Store of the Google App Engine. The KA platform processes this data to obtain useful information and provides some nice visualizations about the learning process.

Although the learning analytics support of KA is useful, we needed to extend it to include other parameters and to personalize some specific information such as the criteria for a student to progress on the platform. Some examples of proposed parameters and how to use them to evaluate the learning process are shown in [Muñoz-Merino, 2013]. Some of these parameters are related to learning effectiveness, learning efficiency, students' time distribution, gamification habits and exercise solving habits. We developed a new learning analytics module for the KA platform for this purpose which is named ALAS-KA (Add on for the Learning Analytics Support in the Khan Academy platform). This module generates individual but also class information about the learning process. This information is available for teachers and experts evaluating the learning process and trying to improve it. The information is helpful for improving the face to face sessions but also for improving future editions of the courses. More details about this extension can be seen in [Ruipérez-Valiente, 2015].

4.6 The Design Process

Based on the experiences of the implementation of SPOCs during two course editions, we can formalize the different steps for the design of SPOC experiences. This formalization can serve for other SPOCs or MOOCs implementations with similar contexts and requirements but, due to the different situations, the design process cannot be generaled for all MOOCs or SPOCs. Figure 1 gives an overview of this formalization. The different boxes represent actions during this process, while the arrows indicate the time flow of the different steps. From the previous sections and our explanations, the relationship of the different phases with our case study is straightforward.

First, the relevant stakeholders should provide a list of educational requirements according to the company or university needs. This list of educational requirements should direct the institutional actions. Based on these requirements, the institution has to decide among the different technological platforms in the market. In most cases, none of the platforms will fulfil all the desired educational requirements. A possible solution is to select and combine several of them, enabling the necessary integrations. In addition, new developments and implementations of additional components to the technological platform can be added in order to accomodate additional educational requirements. The addition of platforms and new educational components implies an effort for the organization. The key stakeholders should make decisions in a trade-off between desired functionality and costs for the organization.

The authoring process should start once the technological platforms and the additional pieces to implement have been decided. This is because the available functionality conditions the educational resources and processes, which in turn influence the way the authoring process should be undertaken. For example, the available functionality on the platforms will condition the types of exercises or the design of the gamification elements.

Regarding the authoring process, there are many aspects for which authoring is needed (e.g. videos, exercises, content structure or the gamification elements). For each of these, the general authoring process is similar. First, course creators should take into account what they can do according to the platform functionality. In addition, they should follow a list of good practices and a suitable methodology in order to improve the learning process. These rules can be given by the organization for the design and creation of different resources. Next, the organization can provide a list of criteria for making homogeneous resources within the organization. These aspects are not usually related to the quality of the resources but to institutional aspects (e.g. inserting a logo at the end of each video) or other homogeneity aspects (e.g. using certain colours for the exercises). These general rules (about methodology and homogeneity) are necessary as typical SPOC environments have a lot of teachers and course creators and there is a need for resource quality and general coordination.

Each educational resource can be created with a specific authoring tool. The authoring tool can be an existing software component or a new one. As well, the authoring tool can be a set of templates that course creators fill in. The type of authoring tool will depend on the specific aspect to tackle (difficulty for teachers, type of resources, expected output, etc.)

Once each of the educational resources is created, all of them should be stored and managed in a uniform way. In addition, the different resources should be properly related (e.g. which exercises are related to which video and topics in the content structure).

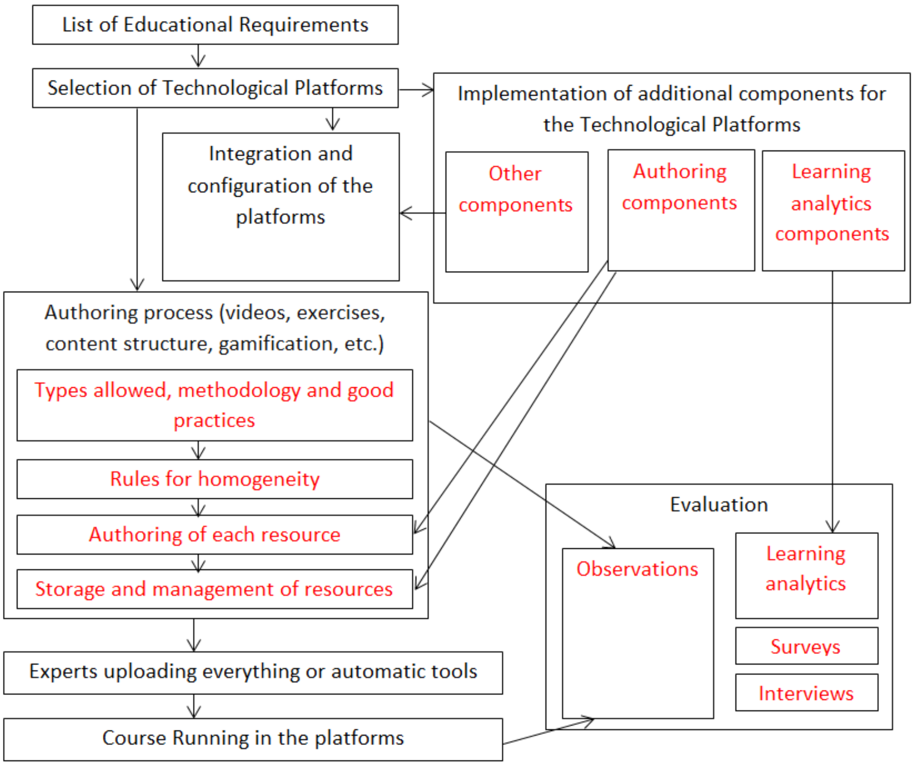

Figure 1: The Design process for SPOCs

The completed resources should usually be uploaded by experts into the platform. In the case of the Khan Academy platform, many teachers cannot manage this final step as it is very difficult without a technological background. The final step of uploading all the resources (e.g. videos, exercises, content structure or gamification challenges) usually must be done by experts. Alternatively, an automated application might be created to manage all this uploading process.

The evaluation of the course should take into account direct observations on the platforms, on the authoring process and the courses running. In addition, surveys, interviews or the results from the learning analytics modules should be taken into account. The desired learning analytic measures should be implemented as an additional component if they are not present in the selected platforms. With all of the results, decisions should be made about modifications for the next editions in the authoring process, new components to develop and the platform configuration.

5 Evaluation of the SPOCs

This section offers an evaluation of the results of the different courses based on some selected parameters such as the number of exercises accessed, number of videos accessed, number of exercises correctly solved, number of videos completed or time spent on the platform. The main purposes of the evaluation, as pointed out in the introduction, are:

1) Compare the activity results in these SPOCs with previous results in MOOCs.
2) Compare the results in the different courses to find the differences between different types of courses (physics, mathematics and chemistry).
3) Analyse how the videos and exercises were used before, during and after the face to face sessions.

For all the measured metrics we have taken into account only users who logged in at least once into the Khan Academy platform; a total number of 81 students for Physics 2012, 163 students for Physics 2013, 73 students for Chemistry and 243 students for Mathematics; additionally this implies that 79%, 90%, 80% and 87% of the students who enrolled in the degrees, also accessed the Khan Academy platform respectively.

In Figures 2 to 5 we have five intervals that indicate in a cumulative bar chart the percentage of students in each case (less than 20% of exercises accessed, between 20 and 40% between 40 and 60%, between 60 and 80%, and more than 80%). Figure 2 represents the percentage of exercises which have been accessed in each course and also on average. Figure 3 shows the same information for the percentage of exercises that have been solved at least once correctly. Figure 4 shows the percentage of videos accessed, while figure 5 presents the percentage of videos watched right through.

Regarding the comparison of these results in SPOCs with respect to MOOCs, we can see that high dropout rates (with more than 85% in most of the state of the art MOOCs) are considered a big issue in MOOCs. The dropout rate in MOOCs is usually used as an indicator of their success. In these SPOCs, the success should be interpreted in a different way and the success is dependent on the purpose of the SPOCs. The students did not need to solve all the exercises and watch all the videos, but only those for topics with which they had difficulties, possibly because they have missed them in the high school. The purpose of the courses is not to review all the materials and solve correctly all the exercises, but to review those materials which students did not understand well from high school. We set a threshold of 20% because on average, we estimate that a student should have problems in around 15-20% of the topics, although not all the students have problems in the same topics. This is based on our experience from previous years. For example, if we consider having more than 20% for the respective indicators from Figure 2 to Figure 5 as a cut-off for considering that students took advantage of the approach, we see that only about 40-50% of the students had values less than 20% for the respective indicators. This might indicate that around 50-60% of the students took advantage of this approach as they made use of the platform enough to review the desired concepts. Therefore, in a SPOCs environment, we can know the purpose of the course, and so define success in a more precise way. When setting up rules of this type that consider the purpose of the course, the indicator of success related to activity use is different from typical definitions of dropout rates in MOOCs. This redefinition of success with a new proposed indicator adapted to the context might mean that dropout rates are not an issue, as in the presented context, and as opposed to dropout rates in MOOCs.

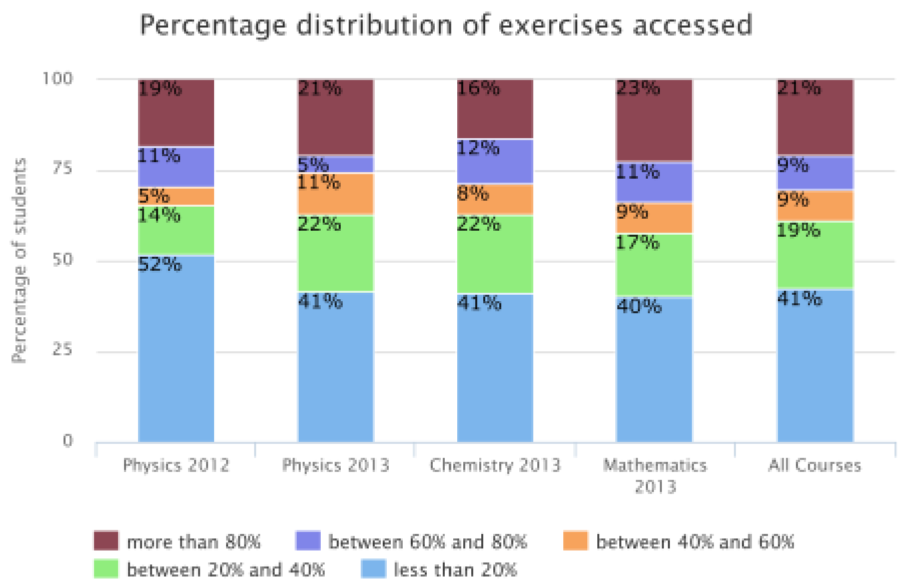

Figure 2. Cummulative bar chart for the distribution of exercises accessed.

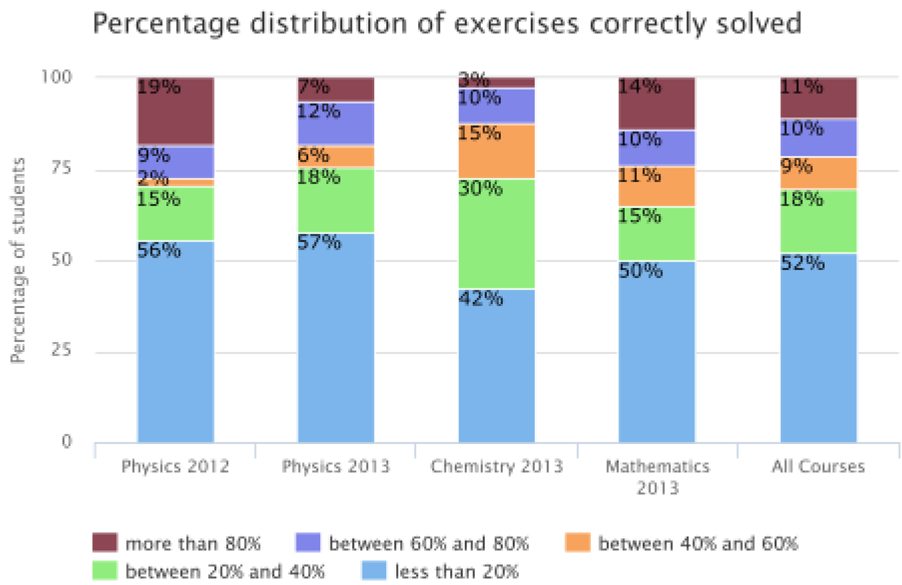

Figure 3. Cummulative bar chart for the distribution of exercises correctly solved at least once.

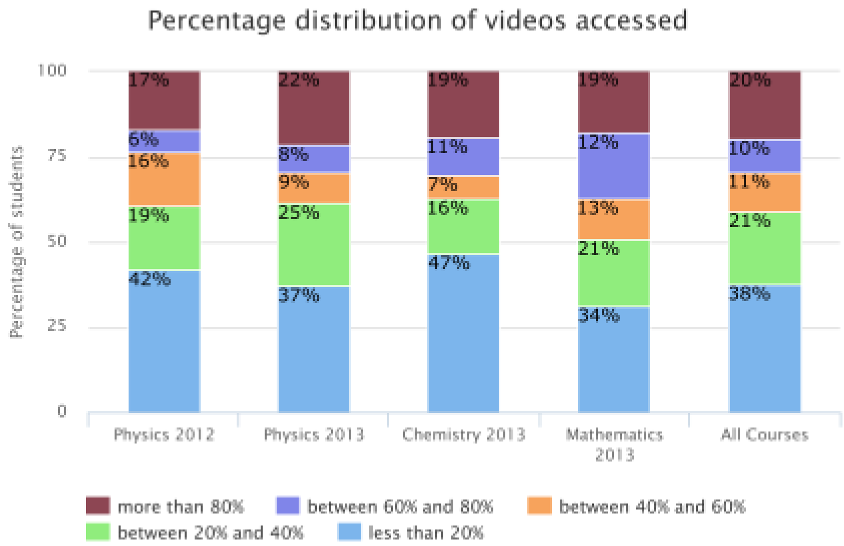

Figure 4. Cummulative bar chart for the distribution of videos accessed.

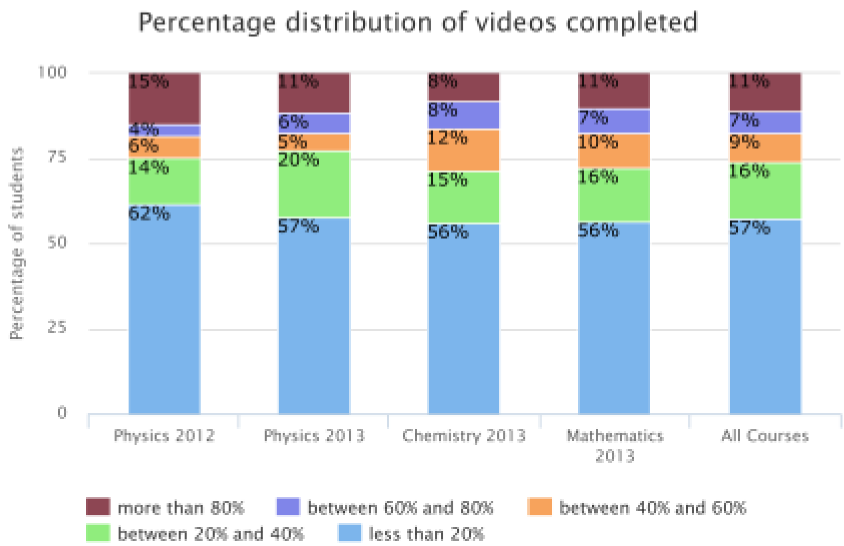

Figure 5. Cummulative bar chart for the distribution of videos completed.

Regarding the comparison of the results for the different types of courses, we can see that, in general, the distributions of the different indicators are quite similar among the different courses. There are some differences with respect to Physics 2012 because there were more multiple choice exercises for this edition, which were easier than the parametric exercises for the rest of the courses. Regarding exercises correctly solved, the distribution of Mathematics is the most uniform in all intervals and also the most similar to the average distribution (taking into account all courses) and Chemistry has a distribution which decreases monotonically in each interval. It is interesting to find that the exercise and video access results are similar on average but the percentages of exercises solved are slightly above the percentages for video completions. Also, we can note that the biggest difference between videos accessed and completed is in the Mathematics course.

Regarding the comparison of the results for different types of courses, the last analysis is related to the time spent on exercises and videos. The time spent on these activities takes into account all the time that a student is with that video or has the exercise open, including also the time when the student may have left to view other websites.

The average time students have spent solving exercises are 99, 105, 143 and 123 minutes whereas for videos the average student have spent 120, 139, 110 and 125 minutes watching videos for the Physics 2012, Physics 2013, Chemistry and Mathematics courses respectively. For Mathematics, the time spent in exercises and videos is very similar, which indicates that the amount of exercise and video work has been well balanced for students. In the case of Physics 2012 and Physics 2013 the amount of time spent in videos has been considerably greater than the amount of time spent in exercises. On the other hand, the amount of time spent in Chemistry has been much greater on exercises than videos. This increase of time makes sense because Chemistry has 49 exercises which is more than the other courses; but this should be further investigated because exercises could be too demanding and students might be struggling.

Table 2 shows the percentage distribution of students in five intervals of time for exercises and Table 3 the distribution of time spent in videos. Approximately half of the students who logged into the platform have invested less than 60 minutes in exercises and another 60 minutes in videos. We can notice some differences, such as Chemistry has the highest percentage of students spending more than 240 minutes in exercises or Physics 2013 having the highest percentage of students spending more than 240 minutes. Most of these results are strongly related to the distribution that we have seen previously about exercises and videos.

Percentage of students	**Physics 2012**	**Physics 2013**	**Chemistry 2013**	**Mathematics 2013**	**All Courses**
[< 60] min	56,8 %	46,7 %	46,6 %	47,7 %	48,6 %
[≥ 60 & < 120] min	11,1 %	19,8 %	15,1 %	19,8 %	17,9 %
[≥ 120 & < 180] min	12,3 %	14,4 %	9,6 %	10,3 %	11,7 %
[≥ 180 & < 240] min	9,9 %	7,2 %	8,2 %	6,6 %	7,4 %
[≥ 240] min	9,9 %	12,0 %	20,5 %	15,6 %	14,4 %

Table 2. Percentage of students in each time interval for the time spent solving exercises.

Percentage of students	**Physics 2012**	**Physics 2013**	**Chemistry 2013**	**Mathematics 2013**	**All Courses**
[< 60] min	46,9 %	43,7 %	47,9 %	45,7 %	45,6 %
[≥ 60 & < 120] min	18,5 %	15,0 %	15,1 %	16,5 %	16,1 %
[≥ 120 & < 180] min	9,9 %	10,2 %	11,0 %	9,5 %	9,9 %
[≥ 180 & < 240] min	6,2 %	10,2 %	11,0 %	10,7 %	9,9 %
[≥ 240] min	18,5 %	21,0 %	15,1 %	17,7 %	18,4 %

Table 3. Percentage of students in each time interval for the time spent watching videos.

Some factors that might affect the values of these indicators and the differences among courses are the following: the level of difficulty of the problems, the quality of videos and exercises, topics with greater misconceptions, and the number of problems.

Finally, it is important to point out that all the previous statistics are related to the general activity of the students with the SPOCs, i.e. these data include the students activity during August (previous to the face to face lessons), 1st week of September (when the face to face lessons took place) and the rest of September (after the face to face sessions took place). Table 4 presents the number of accesses and the time spent in videos and exercises divided by these three periods. If we divide the student activity during these three periods, we observe that most of the activity took place before the face to face lessons (as expected and recommended to the students), some activity took place during the face to face sessions, and almost no activity took place after the face to face sessions.

Period of time	**Number of exercises accessed**	**Time spent on exercises**	**Number of videos accessed**	**Time spent on videos**
August (before the face to face sessions)	66.765	92.468	91.086	65.087
1st week of September (during the face to face sessions)	3.890	4.104	4.991	3.870

September (after the face to face sessions)	29	31	335	216

Table 4. Student activity divided by three periods: before, after and during the face to face sessions (time given in minutes)

6 Conclusions and Future Work

This article presents a list of different challenges encountered while applying MOOC technology and typical MOOC resources to the zero-level courses at the Universidad Carlos III de Madrid during two years. Some solutions adopted and lessons learned from the experiences are explained. In addition, a formalization of the design process of SPOCs is provided, which can be applied in similar contexts and situations.

Among the challenges for the creation of educational resources (videos and exercises) are providing teachers with best practices, homogeneity of materials, enabling teachers with authoring tools which they find easy to understand, providing teachers with continuous support during the process, and centralizing all generated materials so that experts can do the final upload. These challenges require a structured methodology for the creation of educational contents. Authoring tools had to be implemented to enable this process.

Apart from teachers, resources are required: for helping teachers to create videos and exercises, for formatting some types of exercises, to set up the platforms, and for making software adaptations to the KA platform. Based on these experiences, UC3M created an educational technology unit UTEID to help with these tasks.

The introduction of the SPOCs meant that many of the students knew the concepts covered in the videos and the exercises before the face to face sessions, so this had an effect on the September face to face sessions as more active learning methodologies were applied in the face to face sessions.

The evaluation in terms of use of videos and exercises revealed that the proportion of students that took advantage of the approach might be around 50-60% of the students, considering students with more than 20% in the respective indicators. These rates are fine as opposed to the typical dropout rates in MOOCs. With the introduction of the SPOCs, we can know the specific purpose of the course, the audience to which it is focused, etc. and define success in terms other than just the dropout rate.

The comparison among different courses (Mathematics, Physics and Chemistry) did not reveal important differences in terms of type of activity. Further analysis would be required in future experiences to investigate the effect on the results of the design of each course, the population of the students, and the content of each course.

Most of the use of the SPOCs took place before the face to face sessions, some during the face to face sessions and almost nothing after the face to face sessions.

The Universidad Carlos III de Madrid continued developing these experiences and improving their content during year 2014 using the Khan Academy platform. In year 2015, the university changed the MOOC platform to Open edX. The videos and exercises were adapted from one platform to the other.

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