Using a SPOC to flip the classroom

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***Abstract*— The benefits of using SPOC platforms into face-to-face education are yet to be completely analysed. In this work we propose to use SPOCs and video contents to flip the classroom. The objective is to improve the involvement and satisfaction of students with the course, to reduce the drop-out rates and to improve the face-to-face course success rate. We apply these ideas to an undergraduate first year course on Data Structures and Algorithms. The study is validated by collecting data from two consecutive editions of the course, one in which the flipped classroom model and videos were used and other in which they were not. The gathered data included online data about the students' interaction with the SPOC materials and offline data collected during lectures and exams. In the edition where the SPOC materials were available, we have observed a correlation between the students' final marks and their percentage rate of video accesses with respect to the total number of accesses, which indicates a better academic performance for students who prefer videos over documents.**

***Keywords*— MOOC;SPOC;flipped classrrom;learning analytics**

I. Introduction

There is a lot of controversy about the use of MOOCs in education. Some authors [1] argue that they are just a means to lower costs and are not the answer to the pedagogical shortcomings of traditional face-to-face lecturing. Others state that most available MOOCs are merely a traditional lecture divided into small chunks in a video format with the addition of some auto-evaluation tests [2]. This type of MOOC where an existing course is simply transferred into an online format is called transferMOOC or, more generally, xMOOC [3, 4].

But not all MOOCs try to mimic online traditional courses. Connectivist MOOCs or cMOOCs promote a more creative and non-teacher centered learning where a special relevance is given to the interaction among students [5]. Fini [6] carries out a survey on students enrolled in the CCK08 course about Connectivism and Connective Knowledge [7] that focuses mainly on evaluating the specific technological tools used in the course.

When a MOOC is used locally as a supplement to classroom teaching, we call it a SPOC or Small Private Online Course [8]. This paper describes an experimental study aimed at testing the hypothesis that SPOCs can be used as very useful learning tools in face-to-face lectures and may have a pedagogical value. The basic goal of the study is to measure the student performance in a flipped classroom model where a SPOC is used within a face-to-face course in comparison with a traditional lecture-based model.

In our experience, there is a high dropout rate and lack of motivation in first year engineering students. In some cases it is just because they do not find the course attractive or interesting, but the main reason is the decrease of motivation as courses gain in complexity as well as the lack of feedback received by students about their performance.

Several published studies prove that students benefit from the use of online videos [9, 10]. In [9], authors show that the satisfaction of students with instructor-made videos was overwhelmingly positive for both online and face-to-face courses. The face-to-face element of instructor-made videos was a key factor in the engagement of the online students that felt more connected to the instructor. In Brecht's work [10], they study the value of video lectures as a supplement of face-to-face lectures. Two interesting conclusions can be drawn from this study. Firstly, that videos with graphics and sounds was the most effective video design and, secondly, that a decrease in the dropout rate of the course is observed when videos are used.

Another study performed at MIT showed that students prefer 'shaky hand drawings that took shape as the professor lectured' to PowerPoint slides [11]. It is also shown in [10] that videos with graphics and sounds were the most learning-effective video design. For this reason, graphical representations and animations are profusely used to describe the operations performed on data structures and algorithms. Evaluation tests are presented to students at the end of each module to test whether students are assimilating the presented concepts.

The use of SPOCs in education offers several advantages to students. Firstly, the video lectures provide students with a greater flexibility. They can watch their contents at their own pace and revisit them as many times as they wish prior to the face-to-face lectures, just to review complex concepts or to prepare for the exams. By performing quizzes after the videos, students can check their progress on the subject. An additional advantage for students is that nowadays the video lecture is a natural media for them and they are completely used to consuming online information.

This new model presents several benefits also for teachers since the use of the online contents will allow them to apply a flipped classroom model. By using this model teachers can better assess how students are following the subject and propose them tasks to actively test their acquired abilities.

In this context, the first milestone of our project was to transform the traditional teaching materials of a course on Data Structures and Algorithm into a SPOC that can be used as a complementary learning tool within a face-to-face course. The online contents constitute the starting point for the different collaborative activities to be carried out during the face-to-face sessions. In addition, data about student interactions were collected and analyzed to check whether the proposed model contributes to incrementing student motivation and performance and reducing dropout rates.

The course contents have been divided into small conceptual units and one or two short videos are used to present each unit. We think that it is important to limit the length of the videos since short videos require less effort from students and allow them to easily locate the video they want to watch or review.

We consider that by combining a SPOC-based learning model with a face-to-face traditional learning one can help students obtain a greater involvement with the subject and a more active participation in lectures. It can also improve student attendance rates, academic performance and level of satisfaction as well as diminish the dropout rates. In order to validate our hypothesis, data related to the students' interaction with the SPOC was collected as well as information about the students' performance and about their level of satisfaction with the course. These data were analyzed and the different dimensions correlated. Finally, a comparison with data about students who followed the same course but in a traditional face-to-face format was carried out in order to assess the impact of these new technologies.

The rest of the article is organized as follows: Section II describes the design of the SPOC and online materials. Section III presents how the use of the SPOC is integrated with the face-to-face lectures. Details about the experimental study and the obtained results are given in Sections IV and V, respectively. Finally, the conclusions of this research are summarized in Section VI.

II. SPOC DESCRIPTION

The presented SPOC is a course on Data Structure and Algorithms whose contents are acquired by students enrolled on different courses in the Undergraduate Degree in Computer Science and the Undergraduate Degree in Electrical Engineering as well as the Joint Undergraduate Degree in Computer Science in Mathematics offered at the Computer Science Faculty in Universidad Autónoma de Madrid.

In general this SPOC can be followed by students enrolled on any Engineering degree related to Computer Science, Information and Communications Technology or scientific degrees in which the use of programming tools is required.

The goal of the course is to provide basic knowledge about the specification, implementation and use of abstract data types and to initiate students into the fundamentals of algorithm design, analysis and implementation. In particular, the course explains concepts related to the stack data structure, sorting algorithms, and complexity analysis.

Fig. 1. Screenshots of some of the video contents (in Spanish). English translation: *Pila* = Stack; *Apilar* = push; *desapilar* = pop; *nodo* = node; *borrar* = delete ; *insertar* = insert.

The course includes different kinds of materials:

- Short learning unit videos (8 min. average) that integrate presentations and animations along with the teacher audio and his interactions with the presentation. For this interaction callouts are used in order to focus student's attention on relevant concepts. Figure 1 shows some screenshots (in Spanish) of one of the videos about the stack data structure. Videos cover approximately half of the contents of the course.
- Documentation in pdf format part of which have a correspondence to videos and others have not.
- Auto-evaluation questions. Students can answer these questions and receive feedback about their answers. This allows students to know whether they understand the presented concepts correctly and if they are able to apply them in an autonomous way.
- Online as well as face-to-face tests that are presented to students at the end of each section. Students have to take three exams in total.

As described in the experimental study section, we want to take several measures about the interaction of students with the SPOC, and to apply Learning Analytics [12] methods to the collected data.

III. Use of the SPOC in a Flipped Classroom

The course duration is 15 weeks with three hours per week divided into two-hour and one-hour slots in different week days. The flipped classroom model is used in the two-hour slot that is organized as follows. Students are asked to review the SPOC materials prior to the lecture. During the first half an hour, the teacher checks in an interactive way that the students have understood the concepts presented in the material, and explains a task that requires students to apply the learned concepts. Students work on the assigned task for an hour. During this time, the teacher helps them by solving questions and clarifying complex concepts. Finally, students make a presentation of the task or take a short test on the lecture's relevant concepts during the last half an hour in the slot.

Students can work on the SPOC materials (videos, exercises and tests) any place and any time: at home, at the lecture room or at the laboratory. The use is also multiple: they can use the materials to learn new concepts, to review difficult points when working on the practical task, or to prepare for the exam.

The use of SPOC elements in face-to-face education presents several advantages. The first one is that SPOC materials are more visual than traditional ones. This makes them more attractive to students and are much easily understood and memorised than textual ones [10] [13].

Secondly, students can absorb concepts at their own pace since they can review the materials when it is more appropriate for them and as many times as they need to. Furthermore, they will use them to prepare the face-to-face lecture in advance.

An additional advantage is that the lecture model changes completely: from a model in which the teacher plays the active role of communicating information and the student is a passive receiver, to a completely different one in which the student plays the main character role and the teacher just walks along with him in his learning process. The learning model evolves from one in which the goal is to learn concepts to another in which the important point is to learn how to perform tasks by applying those concepts. A model based on acquiring competences instead of just learning bare concepts [14].

This new learning model is better than the traditional one in which the student and the teacher are together in the same place and at the same time just for the contents transmission stage but the student is completely alone when he is required to apply the transmitted concepts.

A final advantage of using SPOC elements in face-to-face education is that the teacher can constantly improve the materials based on the data collected about the interaction of students with the SPOC materials (number of accesses, time spent with each item, test results, etc.).

IV. Description of the Experimental Study

The experimental study focuses on comparing students' performance between two consecutive editions (starting on 2013 and 2014, respectively) of a first year course on Data Structure and Algorithms offered in the Electrical Engineering Undergraduate Degree of the Universidad Autónoma de Madrid and taken by around 90 students. Whereas in the 2014 edition, the flipped classroom model was used as well as online videos and documentation, in the 2013 edition, only the online documentation was available for students.

In order to analyze the validity of the proposed approach, a variety of statistical information was extracted from the students' interaction with the SPOC and within the classroom such as the number of times each student accesses each video and each document and the timestamps of students' activity. Additional collected data include the different marks obtained in the online tests, exams and in the practical activities and the student opinions about the course contents and activities.

The collected data was correlated to analyze the relation between the different dimensions of the student activity: their marks in the course, their satisfaction with the course, and their involvement into the course activities. This analysis was used to compare the results obtained by students in 2014 when a SPOC model is used with those obtained in 2013 when no video materials were available, and to provide some insights to whether a SPOC can improve the educational value of a face-to-face course.

V. Results

From the performed analysis we can make several observations. Firstly, as shown in Figure 2, the percentage of students that passed the course with the SPOC model has improved by more than 5 percentage points from 66.3% in 2013 to 71.7% in 2014. In addition, a clear reduction of the dropout rate (computed as the percentage of students that did not take the last exam) has also been observed (from 9.0% in 2013 to 3.3% in 2014).

Another interesting observation is the different access pattern of students from one year to the next. Figure 3 shows the average number of accesses per student for eight documents that were available in both 2013 and 2014 editions. Documents 1 to 4 do not have any related video while documents 5 to 8 do. As it can be observed in this figure, documents with no related video content have roughly maintained the average number of accesses per student per document (acc/stu/doc), from 2.0 acc/st/doc in 2013 to 1.9 acc/stu/doc in 2014. On the other hand, the documents with related video content have experienced a clear reduction in the average accesses per student going down from 5.2 acc/stu/doc in 2013 to 2.7 acc/doc/stu in 2014. This indicates that the videos are an important support for the students' learning process but they do not completely substitute the written materials. With respect to the videos, an average of 1.8 acc/stu/video was observed. In total, this represents an increment in the total traffic of the courseware over 60%, from 28.8 acc/stu to the different materials in 2013 to 46.9 acc/stu in 2014.

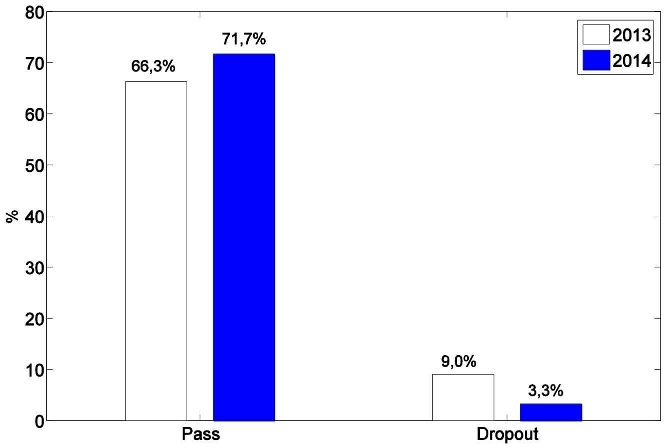

Fig. 2. Pass rate and dropout rate for 2013 and 2014 editions of the course.

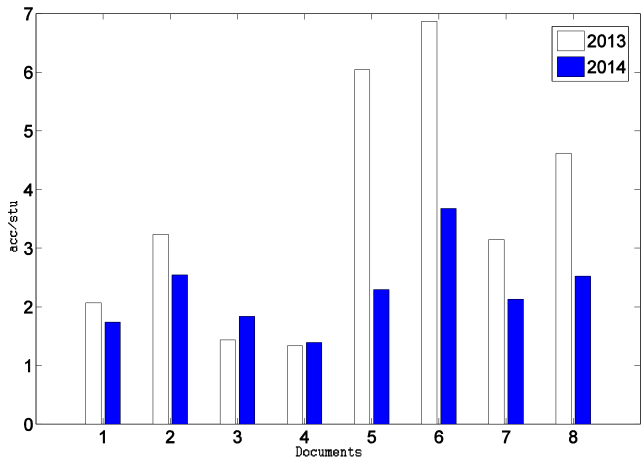

Fig. 3. Average number of acceses to documents per student. Documents 1 to 4 do not have a related video. Documents 5 to 8 do.

Figure 4 shows the temporal access patterns of students during the course. The plot indicates the average number of accesses per student and week. Note that although the course duration is 15 weeks, the x axis in this figure extends to 22 weeks because students can retake the final exam at the end of this period.

For the 2014 edition of the course the plots show the number of accesses to the documents (in green) and to the videos (in blue). These two curves are stacked in order to show the total number of accesses as well as the relative contribution of each type of material (documents or videos) to this total. In addition the average number of accesses to documents in 2013 is plotted with a solid black line.

From this plot, we can observe that students accessed documents a higher number of times in 2013 than in 2014. However, in 2014, this is compensated by the number of video accesses. Peaks in the plots indicate the days previous to the different tests and exams. Interestingly, for the final exam (at week 15), videos were the principal source used by students and were accessed over 5 times more than documents during the ten days prior to the final exam. Videos allow students to review difficult concepts once the face-to-face lectures have finished.

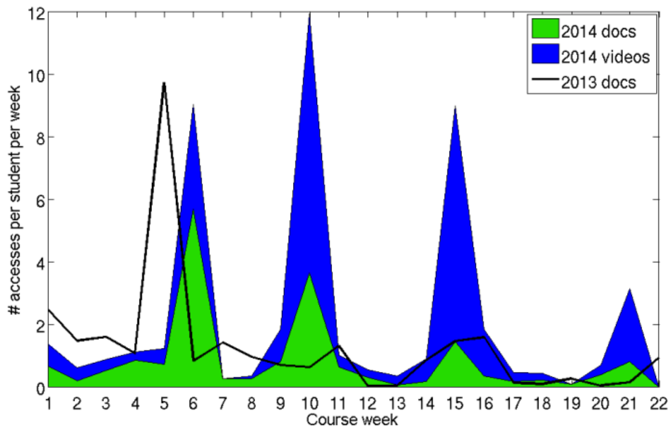

Fig. 4. Average number of accesses per student for the documents in 2013 (shown with a solid line in the plot) and the documents and videos for 2014 (with green and blue areas respectively). The data for 2014 is stacked, meaning that the total amount observed is the accumulate for both videos and documents.

In order to analyze whether a relation exits between marks obtained by students and their content access patterns, we have retrieved the number of times each document and videos was accessed by each student and compared it with the final marks obtained. This analysis is shown in the scatter plots of Figures 5 to 8. Each point in the plots represents one student. Figures 5 and 6 show the total number of accesses to the online contents with respect to the final marks obtained in the 2013 and 2014 editions of the course, respectively. The total number of accesses to videos and documents is plotted for the 2014 edition (Figure 6) and only to documents for the 2013 edition (Figure 5). In Figure 7 the number of accesses to videos and documents is shown separately with respect to the final marks for the 2014 edition. Figure 8 plots the relation between the final marks and the percentage rate of video accesses with respect to the total number of accesses. This means that students who only accessed videos, and not documents, have a percentage rate of 100% in this plot and students who only accessed documents have a percentage rate of 0%.

Figures 5 and 6 show that no correlation exists between the total number of accesses and the final marks either in the 2013 or 2014 editions. An accumulation of students around the median values for the final marks (6.1) and the total number of accesses (39) can also be observed for the 2014 edition. A similar accumulation is observed for the 2013 edition (a final mark of 6 and 24 accesses).

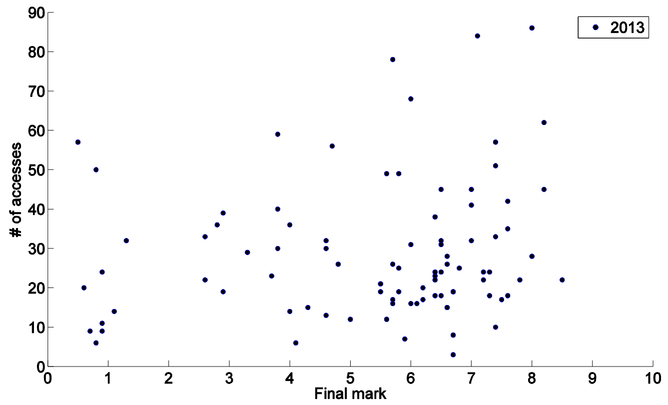

Fig. 5. Total number of acceses to documents in 2013 with respect to the final marks.

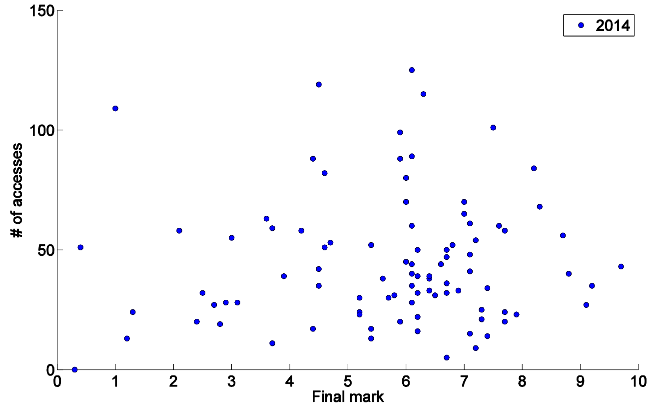

Fig. 6. Total number of acceses to videos and documents in 2014 with respect to the final marks

As shown in Figure 7, no correlation exists between the final marks and the number of accesses to videos or documents. However, as it can be observed in Figure 8, there is an interesting result that shows a significant correlation between the final marks and the percentage rate of video accesses with respect to the total number of accesses. This correlation is small (R=0.34) but the correlation is statistically significant using a p-value=0.01, which indicates that the probability of observing this correlation by chance is below 1%. This correlation means that students who prefer videos over documents have in average a better performance.

Finally, the students' level of satisfaction with the course has also increased moderately from 3.53 to 3.70 in a 5-item likert scale. It is not possible to perform a statistical test on this improvement since we only have access to the average values. More importantly, the number of collected feedback questionnaires has greatly increased from 16.9% to 27.2%, which indicates a higher involvement of students. Note that, these questionnaires are carried out by the university and are optional for students to fill in. In relation to the open questions, no comments about the online materials were given by the students in 2013. In contrast, in 2014, 67% of the open responses appreciate the online materials of the course, especially the videos. Two open responses that can be illustrative are that "*…videos are quite good, since they explain concepts in a clear way and with straightforward examples…*" and "*...the videos are the future of the education…* ".

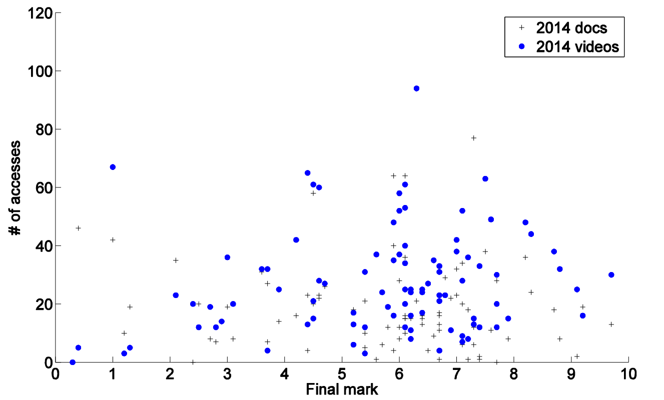

Fig. 7. Number of acceses to videos and documents separatedly with respect to the final marks in 2014

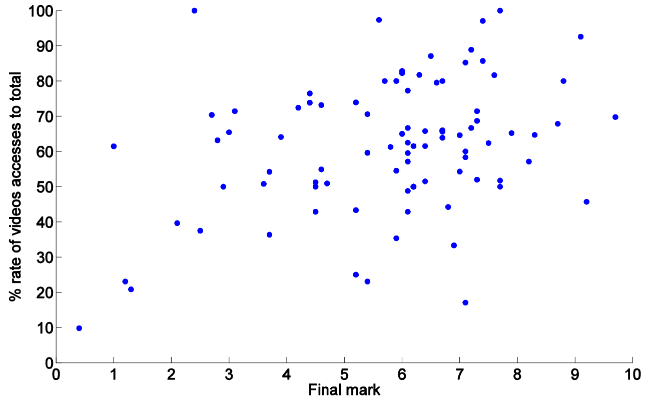

Fig. 8. Relation between final marks and the percentage rate of video accesses with respect to the total number of acceses.

VI. CONCLUSIONS AND FUTURE WORK

In this article we propose the use of SPOC technology in a face-to-face undergraduate course on Data Structures and Algorithms. Students attending the lectures are provided with the support of SPOC materials that allow them to work at their own pace but without being completely decoupled from the course. Two consecutive editions of the course were analyzed, one of them using the SPOC and the flipped classroom model and another edition without these elements.

The analysis was based on access data that were gathered from student interactions with the online contents and quizzes and includes a comparison with previous course editions where students were enrolled only on the face-to-face course. A survey is also carried out to collect the subjective experience of students and correlates all the collected data with the student performance.

The study carried out shows that the use of SPOC technology into a flipped classroom model can improve student involvement, satisfaction and final marks, and reduces the dropout rate with respect to face-to-face education. Another relevant result from this study is that there is a significant correlation between the final marks and the percentage rate of video accesses with respect to the total number of accesses which indicates a better academic performance for students who prefer videos over documents.

A limitation of the presented study is that only two years, 2013 and 2014, are considered. We are working on extending the study to the current academic year in order to monitor the improvements over a longer period of time.

Other future work includes gathering data during face-to-face lectures in order to analyse possible correlations with the online activity of the students and to better understand the students' different learning styles. These data may include attendance rates, doubts laid out by students about online materials, difficulties they have to carry out the practical tasks proposed, time needed to complete the exercises, or number of students requiring extra time to complete the exercises.

It would also be interesting to identify possible correlations with information about the student's background, such as the number of times he has taken the course, or the number of years since he registered on the undergraduate degree.

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