On the Introduction of Flipped Teaching Across Multi-Disciplinary Fields

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***Abstract*— In this article, several Flipped Classroom experiences developed at the Universitat Politècnica de València are shown. The experiences have been developed in different fields: Computer Science, Physics, Plant Breeding and Telecommunication Engineering. This wide range and variety of knowledge areas provides multidisciplinary data, which allows for comparison and contrast. Indeed, this paper offers a general approach to Flipped Teaching and a broad view on how to implement this kind of teaching, which can be useful for other University professors. We address the technological and pedagogical concerns regarding Flipped Teaching and introduce different scenarios in which this approach can introduce benefits both for students and professors.**

Keywords—Flipped Classroom; Flipped Teaching; ICT; Blended Learning.

I. INTRODUCTION

Universities around the world are currently offering numerous and varied learning alternatives: synchronous versus asynchronous lessons, traditionally teaching versus online courses; all of them utilize some online learning tools in their proposals:

- A Learning Management System (LMS), used to organize the courses, distribute digital contents, access multimedia material and facilitate student-to-student and teacher-to-student interaction.
- A digital platform where professors upload teaching materials such as: videos of lectures, screencast videos, etc.
- A system of synchronous e-learning for tutorials, online discussion, etc.

This increase in digital distribution of content is routine, organic, and largely taken for granted on most campuses [1]. Online tools and online teaching materials offer students the opportunity to diversify their learning, and approach it from different perspectives according to their needs, qualifications or even availability. However, the extraordinary amount of online teaching materials may head students towards the self-preparation of the subjects by only using the provided materials and feeling that the attendance to the classroom is redundant. What is more important, this situation can cause lack of motivation, and scarce participation in the classroom.

To change this, classroom activities must be enriching, rewarding and qualitatively different from what is offered online. Improving classroom activities and changing the role of the teacher from a simply deliverer of contents to a real mentor may ensure the complementary role of classroom and online resources for effective learning.

The Flipped Classroom (FC) approach is a pedagogical model that reverses the space and time in which the learning activities —teacher explanation and student work— take place [2]. In FC, the students see the teachers' lectures at home, mainly in the form of short videos (5-10 min), but they can also read articles, or books chapters, among other materials. Therefore, the role of the professor is not only to choose what topic is going to be explained outside the classroom, but also to provide enough materials and find the best activity for developing the given topic in the classroom after having studied the materials provided. In the live class, students assume the main role by implementing the contents that they have previously studied, through exercises, projects and discussions [3].

The FC is based on Blended Learning (BL), and combines direct instruction with constructivist methods in order to achieve a comprehensive approach to the topic. A good FC practice must encourage all the stages of the learning cycle in Bloom's Taxonomy and should increase the commitment and involvement of students in their learning. Furthermore, this method can support the development of some skills that were previously not adequately developed such as independent learning or self-assessment.

The FC method provides the opportunity to use ICTs to leverage teaching, allowing students to be prepared before the lesson, so that in each session students can experience and interact with their peers and with the professor, enhancing the possibilities of a more effective and creative learning in the classroom, as well as providing self-commitment to the subject in agreement to their needs and expectations. In addition, this method allows the professor to gain better insight into student difficulties and learning styles, which is very useful to customize and update later lectures [4].

In sum, there exist a plethora of virtual and online pedagogical materials provided by universities worldwide. All these materials can be used as a kind of substitute or complement to the class (those are the main uses observed in

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our University) or to improve the learning experience. FC has been pointed out as a good way to improve engagement, feedback, and learning. Therefore, the aim of this research was to implement the FC experience across several fields at the UPV. As this research had a multidisciplinary approach, it can be useful for other university professors in a wide range of subjects. The paper is organized in three main chapters: previous experiences at our University, flipped classroom experiences and conclusions.

II. PREVIOUS EXPERIENCES

A. *Information and Comunication Tecniques (ICT)*

At the Universitat Politècnica de València, there are several ICT tools available for professors to use in this new teaching paradigm. All tools are integrated in a Sakai-based Learning Management System (LMS) called *PoliformaT* [5], in use since 2000. This system allows asynchronous communication between professors and students, the exchange of teaching materials and the assessment of students. This is mainly used as a repository of presentations and exercises, although other interactive elements can be integrated, such as online labs or multimedia material.

Of special relevance is the *Politube* video server [6]. This platform enables users to upload their videos and provides access control to their content. These videos are usually 'decontextualized' and do not relate to one single unit or lesson within a course so they can be recycled for different courses. Videos can be:

- Direct recordings or screencasts, as the one shown in Figure 1, where exercises are solved using a classical view of the classroom blackboard.
- *Polimedia* [7]: professional-looking videos recorded on a studio.
- Teaching videos: labs demos.

In addition, there is the possibility to record live lectures and upload them through a video-notes service: *Videoapuntes* [8].

Apart from these asynchronous tools, the UPV launched in 2010 *Polireunion*, a synchronous communication system based on Adobe Connect™ [9], able to create environments where teachers and students can collaborate in real time through a virtual environment accessible via the Internet. *Polireunion* enriches the existing e-learning UPV system and allows for real-time communication between teacher and students, without the need to be physically in the same location. *Polireunion* is mainly used to: i) support tutoring, ii) teach full lectures and iii) promote collaborative activities.

B. *Blended learning*

Transitioning from traditional face-to-face classes to Flipped Classroom experiences requires certain experience with Blended Learning approaches that involve technology-mediated instruction. In previous occasions, we implemented successful experiences on multidisciplinary fields, based on first, synchronous e-learning using Adobe Connect [10] in which technology fosters student-student interaction, collaboration and enhanced motivation. Secondly, we also used video-exercises [11], which are short videos (of about 6-7 minutes) produced using a graphics tablet, a webcam, a microphone and screencast software, in which the professor solves a typical problem, for students to understand the resolution process. Finally, we also offered the usage of Cloud Computing for ubiquitous online computational remote labs [12] to carry out hands-on labs, especially for computer science subjects [13].

This background has paved the way to move one step further and introduce Flipped Classroom approaches as complementary techniques to the broad range of teaching approaches that we are already addressing.

III. FLIPPED CLASSROOM

In this section some experiences developed at the UPV in different fields (Plant Breeding, Computer Science, Physics, and Telecommunication Engineering) are explained. As each area has different pedagogical needs, different flavours of Flipped teaching are presented:

A. *Typical FC case in Plant Breeding*

FC was applied in a Plant breeding course of a Biotechnology degree. Short videos were recorded showing either mathematical demonstrations or theoretical explanations. Then, classroom time was used to clarify concepts and to solve problems involving the equations demonstrated in the visualized videos. In previous courses, classes usually were devoted to theory and then the problems were relegated to homework time.

In this experience, not all the lectures of the course followed the FC methodology, mainly for the lack of recorded materials. However the good results obtained in terms of students engagement, encourage us to keep producing material to complete the whole course with this methodology.

B. *FC and remote labs in Computer Science*

This experience is being carried out in the Master's in Parallel and Distributed Computing at UPV, in which there are different subjects where the students use public Cloud Computing providers such as Amazon Web Services (AWS). By combining the different Cloud services that AWS provides, students create scalable application architectures. For that, they train via a set of self-guided hands-on labs that use the main AWS services.

In this scenario, FC arises as an interesting technique to outsource the common explanation of the main AWS services to a set of videos for students to visualize before entering the hands-on sessions. Therefore, we recorded short videos, of about 10 minutes that describe the most important features and capabilities of each service. We also produced an introductory video for each hands-on lab session that summarises the activities that the student will have to carry out once they have seen the video (Figure 1). This way, the time allocated for the session can be specifically devoted to performing the practice

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session on the remote labs, instead of dedicating time to describe the services that need to be used.

As an additional benefit, this enables students that skip a session to catch up by watching the videos. We produce these videos on a *Macbook* using *Screenflow* which are streamed with *Politube*. We have also experimented with *Polimedia* [7], although it is a limiting tool due to its lack flexibility (it cannot be edited). Additionally, we experimented with *Opencast Matterhorn* to record full classes, although we currently prefer to create content via screencasts, which is a flexible and available technology and its use can be widespread.

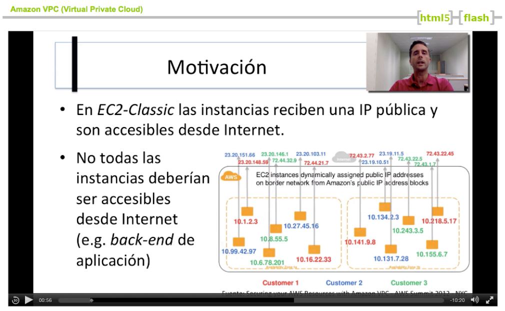

Figure 1: Introductory video

C. *FC and labs in Physics*

The FC method has been used in a Physics course of first year in the Biotechnology degree.

It has been developed in one of the activities of the course, which has the highest level of student participation; the laboratory. Seven educational videos together with seven surveys were prepared as specific material of the FC experience, complementing the lab book. Each video lasts less than 10 minutes, and in them students can watch the main aim of the laboratory, the materials and the steps they should follow in the laboratory. The survey is related to the video, and helps professors know the degree of understanding achieved by the students, both before and during the class.

The class session begins with a review of the class objectives, so a student explains the aim of the lab and sums up the activities they are expected to do in the session. During this explanation the professor can correct some points and clarify all the doubts students may have before starting. Then, students work alone, and the professor can answer every doubt individually (Figure 2). Eventually, the professor clarifies some short theoretical items the lab experience is based on. Students collaborate in this explanation and in the discussion of the results they have obtained.

It has been a successful experience, since students can easily know what they have to do in class in advance. Students are more active, less bored, more concentrated in what they are doing and more relaxed, as they know what comes next in the class. The professor does not work against the clock explaining everything in the live class, and students can usually finish the lab report in class.

Figure 2: Students working in lab of Physics with the support of a professor

D. *FC and collaborative work in Telecomunication Engineering*

FC was applied in a course of wireless communication systems situated in the third year of the telecommunication engineering studies.

The first unit of this course focuses on the review of the main communication concepts that students should have acquired in the previous courses. Usually, some concepts like modulation, propagation, multiplexing and digital communications must be reviewed. Instead of using the classical master class, a number of PoliformaT multimedia modules were created including several virtual labs and screencasts illustrating the topics of interest. Figure 3 depicts one of the virtual labs on digital modulations, integrated in PoliformaT. The virtual lab illustrates the operation of an amplitude modulation system. This kind of concept is hard to understand because of the mathematical complexity and the required reasoning capacity. On clicking in the lab, the students can observe how the system behaves under different conditions, which simplifies the understanding of the concept.

The professor announced the availability of this material in advance, and then requested the students to prepare a given concept before the class in which the concept was going to be explained. In the class, students were organized into teams and prepared a joint presentation using *Google Docs*. All students were equipped with laptops for the parallel distribution of tasks. The final part of the session was dedicated to the presentation of the concepts by the students. They assumed the professor role, while the professor participated adding valuable information or correcting undesirable deviations.

The experience for the students was highly appreciated and motivation to participate and be active in the class grew significantly. Learning outcomes were also satisfactory, being the obtained marks in the unit as high as in previous years.

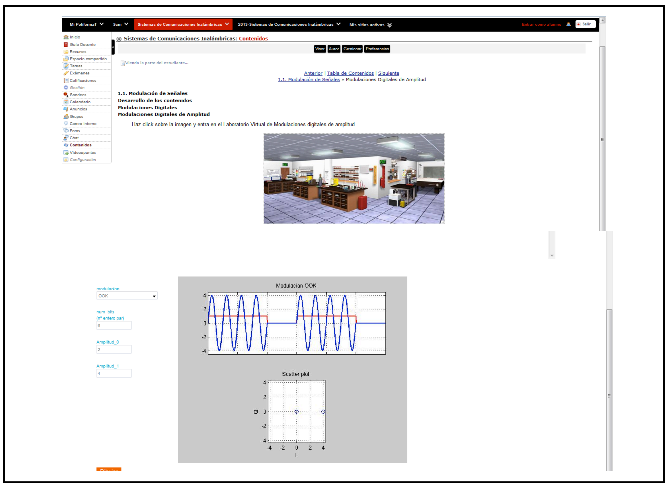

Figure 3: Virtual lab on digital modulations.

E. *General issues*

From the point of view of students, they feel now more comfortable in class than before due to the fact that they come to class with some clues about the topic that is going to be discussed, and this leads to an increase of participation and interaction in the classroom. Students benefit more of class sessions because they have the control of their learning speed unlike classrooms in which they must necessarily follow the instructions of a professor in real time. Furthermore, students can carry out their own research, they can share experiences and they developed transversal skills, such as team work, autonomy, and critical thinking.

From our experience, we can say that although it is hard work to prepare the online material and to organize the classroom activity, the rhythm of the class is more enjoyable than a traditional class.

Finally, Table I depicts the main advantages and disadvantages of this FC experience.

TABLE I. MAIN ADVANTAGES AND DISADVANTAGES

ADVANTAGES	DISADVANTAGES
More time to work on practical issues and to develop transversal skills	More previous work, mainly for the professor
Improvement of classroom environment: higher level of participation, more relaxed mood	Some students cannot follow the class if they do not make the effort of preparing the class in advance

IV. CONCLUSIONS

This paper has described several Flipped Classroom experiences across different fields (Plant Breeding, Computer Science, Physics, and Telecommunication Engineering), where different approaches have been implemented to consider the intricacies and requirements of each subject. So far, the experiences have proved to be successful both for professors and students.

It can be said that an effective FC requires careful and intense preparation and this is not always an easy task for professors. Online teaching materials must be carefully integrated in a clear and motivating manner, and therefore class sessions could be developed as enriching activities.

We encourage other professors to apply this method in their courses, because we believe that it benefits the efficiency of the class and it is the best way the students can achieve the required knowledge at the same time they develop other skills.

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