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Micro-Flip Teaching with e-learning Resources in Aerospace Engineering Mathematics: a Case Study

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Abstract— **In this study, a type of e-learning resource (called polimedias) have been used to cover the main ideas of numerical and functional series and as an important part of a micro flip-teaching methodology in the subject of Mathematics I of the Aerospace Engineering degree. Using this methodology in the ARA group has led to an improvement in the grades and in the understanding of the subject. Students have shown a very positive opinion of the different steps in the micro flip-teaching methodology. The elaboration and usage of polimedias have been proven to be a very flexible tool that adapts perfectly to the new teaching methodology. These results favor extending this methodology to more items of the subject with the objective of a gradual adaptation to a whole FT methodology.**

Index Terms— **Flip-teaching, Polimedias, e-learning, Mathematics.**

I. Introduction

NEW technologies have allowed the development of new ways of communication and transmission of knowledge. Nowadays, students have an immense amount of information on the network, accessible from anywhere at any time. This ease of resources has allowed teachers to implement new learning methodologies in the classroom, increasing the student's active role in the learning process. Indeed, teaching is becoming more than a mere transmission of information, since the information is almost everywhere: teaching should focus in learning how to learn. It is a priority to discern the useful information, to manage big quantities of data and to promote a critical spirit for the assessment of the information. In a statement to the World Economic Forum, Paul Kruchoski said that "The university of tomorrow will also focus on 'learning to learn' [1]. Learning is a lifelong process and with today's pace of change, everyone will need the tools to learn throughout life". This process of learning to learn will need the aforementioned more active role of the students and a more flexible pace, able to adapt to the individual needs of the learners.

Among the new forms of transmission of knowledge, it is worth mentioning MOOCs (Massive Open Online Courses) that have emerged in recent years and have attracted the attention of both students and teachers. Unlike traditional face-to-face education, MOOCs have a few temporal and spatial limitations: students can access the course at any time and in any place, as long as they have access to the Internet [2]. Platforms like EdX, Coursera, and Udacity bring together a huge collection of MOOCs from many prestigious universities. MOOCs can be considered one of the most important steps in the direction of online autonomous learning. Nevertheless, their impersonal nature can be considered as an important drawback.

In a smaller scale, UPV has been developing POLIMEDIA, consisting of a system for the creation of multimedia contents and with the aim to support face-to-face teaching. POLIMEDIA ranges from the preparation of the teaching material to the distribution through different media (TV, Internet, CD, etc.) and as a resource integrated in educational PoliformaT platform (Sakai), employed at the Technical University of Valencia (Universitat Politècnica de Valencia). This teaching material consists mainly in the production of videos (polimedias) with different options of edition and with duration of no more than 10 minutes in which a concept or an idea is explained. The elaboration of polimedias has been proven to be a very flexible tool that adapts perfectly to the new teaching methodologies such as Flip-Teaching (FT) or blended-learning (BL). These methodologies allow establishing "a link between activities outside and inside the classroom" [3].

Among the new methodologies employed nowadays favoring an active learning process we find blended methodologies, defined as the combination of traditional and interactive modes of classroom instruction with learning technologies [4]. Other researchers define blended learning as a combination of face-to-face and online learning instruction with the aim of complementing each other [5].

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These methodologies combine parts of the traditional, online and flipped modes. Except for the traditional mode, technology is strongly related with the online education and partly with the flipped mode. Literature on e-learning is growing immensely, emphasizing student learning effectiveness [6].

In traditional educational models, learning can be divided into two phases: transmission and assimilation [7,8]. The transmission phase consists mainly in conference-based teaching in which students play a passive role [9]. In the assimilation phase, students apply the new information acquired in their assignments, laboratory practices or in-group activities [10]. In this second phase, teachers can be present (laboratory practices) or absent (tasks outside the classroom).

The FT methodology reverses the two main activities of the traditional model: lessons are taught outside the classroom through and the exercises or assignments are solved in class with practical individual or cooperative activities [8], transforming the classroom into a meeting and debate point [11]. The interaction in the classroom can occur in different ways: the most common models include problem solving, cooperative resolution, and teacher-student interaction based on quizzes or problems. This interaction between the teacher, the students and the content allows establishing the so-called "interactive triangle" [12]. These authors study how interactivity is related to the mechanisms of educational influence.

It has been proved that a great effort is required to apply some new methodologies in the classroom [13,14]. It has also been estimated that approximately two years are needed to consolidate and stabilize a complete educational model. One way to adapt to a new educational methodology is to use gradually different stages, and measuring the impact of each one on the students' learning process. These small steps or processes add the word micro as a prefix. The total effort of introducing a new methodology is therefore divided in several steps, helping the teachers to achieve satisfactory results, and a smoother adaptation of students to new forms of learning.

II. Polimedias in FT

One of the simplest applications of polimedias is based on its use to facilitate learning outside the classroom. In this study, a Micro-Flip Teaching (MFT) method has been employed: the main characteristic of this model is that it is not necessary to apply it to the whole subject, but to the main ideas that the teacher wants to highlight. For its application, we used polimedias as the main tool (see Fig.1). The MFT model has been tested with a positive impact on learning improvement. The polimedia-MFT model that has been applied consists of three stages: outside the classroom (OC), linking activity (LA) and inside the classroom (IC) (see Fig. 2)

A. *Outside the Classroom*

This phase involves all the activities that take place outside the classroom. It is at this stage where polimedias are used with the aim of transmitting a significant part of knowledge to the student without the teacher being present. The polimedias have an estimated duration of 10 minutes, to maximize the attention and predisposition (see Fig. 1). In addition, each video is accompanied by additional material that allows them to evaluate the acquisition of knowledge and skills.

B. *Linking Activities*

It consists in the activities that are used to establish a connection between the activities inside and outside the classroom. This activity can consist in the realization of a work or a questionnaire in which the students apply the concepts explained in the polimedia. These activities are completed through the platform for automatic evaluation. This provides immediate feedback to the student, allowing him to assess his/her progress. The duration of this activity is thirty minutes maximum.

Fig. 1. Example of Polimedia about Series

C. *Inside the Classroom*

Depending on the responses of the students to the questionnaire the teacher is able to know the deficiencies and the degree of learning previously to meet them at the classroom. This information is used to design the activities of this stage. Activity in the classroom can be structured in different ways:

- The results of the link activity can be used as a teaching resource. A brief discussion can be established on the results obtained, whether they are correct or erroneous.
- The teacher tries to clarify the concepts that the students have not been able to assimilate.
- A group test is carried out in which the learning resources generated up to that moment are used.

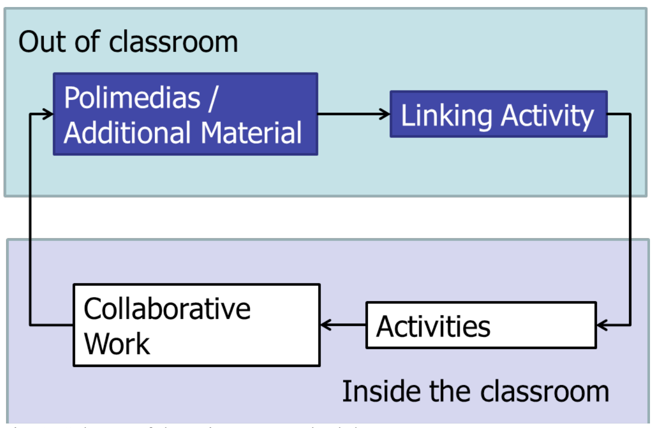

Fig. 2. Scheme of the Micro-FT methodology

The teacher chooses the form that best suits the dynamics of the group or the degree of assimilation of the concepts.

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III. Application of the Polimedia-MFT Methodology

Mathematics I is an obligatory annual subject with 12 ETCS, of which 75% corresponds to Theory / Problems (TP) sessions and the remaining 25% to laboratory practices (LP), taught during the first year of the Aerospace Engineering degree at the School of Design Engineering (ETSID) of the UPV.

Students are divided into two groups: ARA (High Academic Performance), with teaching in English, and NARA with teaching in Spanish. Both groups, regardless the names, follow the same methodology in math classes and have the same program, assignments and exams.

Nevertheless, the polimedia-MFT methodology was applied to the students of the ARA group during the academic year 2017/2018 in a part of the syllabus, corresponding to the chapter of numerical and functional series. The students of the non-ARA group were able to access the same resources but the methodology was not applied.

There were 124 students, 50 belonging to ARA group and 74 belonging to NARA. 32 students answered the survey about the polimedia-MFT methodology.

IV. Results and Opinions

After the application of the new methodology, students are assessed about series. A simple two-factor ANOVA test was conducted to analyze the differences among group means in the sample.

TABLE I
Summary: Series Grades

	ARA	NARA	TOTAL
Size	50	74	124
Average	7.7774	6.75676	7.16416
Std. Deviation	1.71342	2.16416	2.04987
Variation Coeff.	22.03%	32.03%	28.60%
Minimum	2.87	0.99	0.99
Maximum	10	10	10
Range	7.13	9.01	9.01

The ANOVA table decomposes the variance of the grades of the Series exam into two components: a between group component and an intra-group component. The F-ratio, equal to 7.80674, is the quotient between the estimated between-groups and the estimated intra-groups. Since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean of Series grades when we consider the factor ARA/NARA with a level of significance of 5%. Furthermore, the average of grades in ARA group is significantly greater than the average of grades in NARA group.

TABLE II
ANOVA for Series Grades

Source	Between Groups	Intra Groups	Total (Corr.)
Sum of Squares	31.0834	485.756	516.84
D.F.	1	122	123
Average Square	31.0834	3.98161	
F-Value	7.81		
P-Value	0.006		

However this situation does not occur in the other exams of the subject (C1, C2 and Algebra). A simple two-factor ANOVA for these exams led to the following P-Values: 0.6395 for Algebra, 0.3001 for C1 and 0.5620 for C2, and since the P-values are greater than 0.05, there is not a statistically significant difference between the means when we consider the factor ARA/NARA.

TABLE III
Student's opinion about the new methodology

Do you think that the polimedia-MFT methodology helped you in your learning process?	
Nothing	0%
A little	1%
Quite	15%
Very much	84%

A survey was performed to evaluate the experience with the polimedia-MFT methodology. The survey aimed to collect the degree of acceptance and satisfaction. The first item that students valued is the perception of utility of the new methodology. The results are shown in Table 3.

As can be seen, there has been a wide acceptance of this methodology: 99% of the students have a positive perception. With regard to the linking activities, students have shown very positive acceptance as shown in Table 4.

TABLE IV
Student's opinion about the linking activities

Did the linking activities help you to learn?	
Nothing	0%
A little	6%
Quite	24%
Very much	70%

The activities in class have also obtained very good results. The results are presented in Table 5. Nevertheless, in this case, more disparity of results is observed. This may be due to the different techniques used during the activities.

TABLE V
Student's opinion about the in-class activities

Did the activities in the classroom help you in your learning?	
Nothing	0%
A little	11%
Quite	41%
Very much	48%

Finally, the students were asked about the materials used for the activities outside the classroom. Specifically, the polimedias had very good opinions. The results are shown in Table 6.

TABLE VI
Student's opinion about polimedias

Did the activities in the classroom help you in your learning?	
Not useful	0%
Little useful	5%
Quite useful	55%
Very useful	40%

V. Conclusions

In this study, polimedias have been used to cover the main ideas of numerical and functional series, and as an important part of a micro flip-teaching methodology in the subject of Mathematics I of the Aerospace Engineering degree. Using this methodology in the ARA group has led to an improvement in the grades and in the understanding of the subject. Students have shown a very positive opinion of the different steps in the micro flip-teaching methodology. In the out-of-class stage, polimedia videos have been employed as teaching material with duration of no more than 10 minutes, in which a concept or an idea is explained. The elaboration of polimedias has been proven to be a very flexible tool that adapts perfectly to the new teaching methodology. These results favor extending this methodology to more items of the subject with the objective of a gradual adaptation to a whole FT methodology.

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