METHODOLOGIES FOR TEACHING AN ENGINEERING SUBJECT IN DIFFERENT COUNTRIES: COMPARISON AND RESULTS

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Abstract

Engineering or technical degrees are difficult to teach and, consequently, have always been characterized by a large number of academic failures. Therefore, continuous assessment has been applied to classes of similar content, related to Port and Coastal Engineering during these last years in three different Universities worldwide: University of La Republica (Montevideo, Uruguay), Nova de Lisboa (Portugal) and Cadiz (Spain).

This paper presents different methodologies used to teach and evaluate these courses at each University, together with the results of the evaluations of the students who were enrolled during the current and previous stages. Generally, a decrease in the number of students who abandon the classes has been noticed together with an increase in the percentage of students who pass and an improvement of their grades, except at the University Nova de Lisboa were the results have remained stable. In addition, changes experienced in the courses are discussed herein by comparing the percentage of success in the different locations. Moreover, influence of the different methodologies and the possible reasons for these changes are also presented and analysed.

As a conclusion, the improvement in educational outcomes has been achieved through the concurrence of different factors: the existence of more frequent written and/or oral exams, practical examples of case studies as well as access to specific tools of new technology and to documentation specifically prepared for the classes and available online.

Evidently, the above mentioned tasks require a strong commitment and great effort by the teaching staff. If human resources diminish, as it is happening in Spain and Portugal due to the budget reduction in education, two difficult questions arise: For how long will teachers' current effort be maintained? What impact will have their complete devotion to teaching in their research performance?

Keywords: Innovation, technology, teaching methodology.

1 INTRODUCTION

A high percentage of quit together with bad marks are the main characteristics of learning an engineering or technical degree at the Universities all over the world [1]. Trying to find a remedy for this endless academic failure, continuous assessment has been applied to classes of similar content, related to Port and Coastal Engineering during these last years in three different Universities worldwide: Universidad de la Republica (Montevideo, Uruguay), Universidade Nova de Lisboa (Portugal) and University of Cadiz (Spain).

The aim of this paper is to present the different teaching and evaluation methods utilised at each University. Comparison of these methodologies and the results of the evaluations of the students who were enrolled are presented herein.

2 CONTENTS AND GOALS OF THE SUBJECTS AT THE DIFFERENT LOCATIONS

2.1 FCT/UNL, Lisboa

Faculdade de Ciencias e Tecnologia (Faculty of Science and Technology - FCT) is one of the nine academic units of Universidade Nova de Lisboa (UNL). The FCT/UNL campus, located in Monte de

Caparica, south from Lisbon, was founded in 1977. FCT/UNL is one of the most prestigious Portuguese public schools of science and engineering today, with a total enrolment of cca. 7500 students, of which nearly 1400 are postgraduate students (MSc and PhD) (http://www.fct.unl.pt/en/faculty).

FCT/UNL has the following departments/Sectors: Environmental Sciences and Engineering (DCEA); Materials Science (DCM); Mechanical and Industrial Engineering (DEMI); Physics (DF); Informatics (DI); Mathematics (DM); Chemistry (DQ); Earth Sciences (DCT); Life Sciences (DCV); Electrical Engineering (DEE); Civil Engineering (DEC); Applied Social Sciences (DCSA); Conservation and Restoration (DCR); Hydrosphere Ecology (GDEH). Moreover, the master courses can be followed since the beginning (Integrated Master Courses, 5 years and 300 ECTS) or as a postgraduate course (2 years and 120 ECTS). It should be noted that European Credit Transfer and Accumulation System (ECTS) is a standard for comparing the study attainment and performance of students of higher education across the European Union. One academic year corresponds to 60 ECTS credits that are equivalent to 1500–1800 hours of study in all countries and is used to facilitate transfer and progression throughout the European Union.

The FCT/UNL started imparting a signature related with coastal engineering in the Master of Science of Civil Engineering in 2010-2011. This subject was included in the optional curricular unit of “Railways and Ports Infrastructures (IFP)”, in the 2nd Cycle Master Course at DEC. After that, the course was opened as an optional subject as well, for the integrated Master of Science and being given in the 2nd semester of the 1st year for the Master of Science and of the 4th year for the integrated Master of Science. The signature corresponds to 3 credits (ECTs) in a total of 120 ECTs for the Master of Science and a total of 300 ECTS for the integrated Master. The course has a total of 56 class hours, corresponding half of hours to Coastal Engineering. This postgraduate course has a “numerus clausus” policy (usually less than 25 vacancies).

The classes are divided into ports and railways infrastructures, as each area is quite specific. It is the only signature related with ocean maritime hydraulics. The IFP design principles are introduced in this curricular unit presenting the concepts and knowledge about the loads action, the design procedure and the tools that support the design. The main techniques for monitoring and maintenance of IFP are also presented. The coastal engineering syllabus is divided in two parts. The first part regards to Port Infrastructures and includes concepts of maritime traffic and transport, natural protected conditions, construction, types of vessels and cargo load and unloaded requirements. The second part concerns to Maritime hydraulics and include the study of the hydrodynamic actions, types of maritime structures and the design of rubble mound breakwaters.

Regarding port infrastructures, the course consists of a set of theoretical-practical classes, in which the students become familiar with basic principles, from aspects related to management concepts to design, construction, monitoring and maintenance of maritime structures. Thus, students acquire the necessary technical and scientific bases that allow them to solve, in future, engineering problems related to the maritime works and railway infrastructures, being able to integrate work teams. Applied learning is encouraged by performing small design exercises and, when the number of students is sufficiently reduced, also through a research work, with a report delivery and oral defence.

During these four years, the ratio of students who quit or did not take the final exam in Coastal Engineering was around 15% of the total number of enrolled students. Most of the students that enrolled the final exam approved, making the percentage of approved students being around 85%.

2.2 FIng/UdelaR, Montevideo

The Faculty of Engineering (Fing, http:www.fing.edu.uy/imfia) is part of the University of the Republic (UdelaR), the only public University in Uruguay and it is in Montevideo. In it are currently 9 engineering careers: Surveying, Civil, Electrical, Computer, Mechanical, Naval, Production, Chemistry and Food; 3 technical programs: Mechanical, Computer and Mapping and 2 degrees: in Atmospheric Sciences (along with other faculties) and in Computer Science. UdelaR, is immersed in a few years in a context of massive, which poses major challenges. The massive implies, among other things, select and rank content, implement alternative teaching methodologies, incorporate alternative systems of evaluation, which requires a permanent updating and specific support for teachers in the various aspects that make up the teaching function.

It keeps track of student academic progress by the teaching unit of the FIng (UEFI). The distribution in stripes of credit active students of the careers of engineering to March 2014 (report UEFI, 2014)

shows, for all the students of FIng, 45.1 active students in the first semester credits Strip (0 and between 1 and 44 credits) being a 42.4 for Civil Engineering. A 54.4 does not exceed appropriations corresponding to the first year of racing (from 0 up to 89 credits), being 51 in the Civil case.

The Teaching Unit of Fing (UEFI) keeps track of the academic advance of every student. In March 2014, 45,1% of the active students had earned less than 45 credits (required for fulfil the first academic semester), while 54.4% had earned less than 90 credits (required for fulfilling the first academic year). For Civil Engineering students these figures are 42.4% and 54.4%, respectively (report UEFI, 2014).

The Fing/UdelaR has one signature related with coastal engineering as an optional curricular unit of "(Coastal and maritime hydraulics)", in the 10th semester of the Civil Engineering degree. The signature corresponds to 10 credits in a total of 455 credits.

The coastal engineering syllabus is divided in three main parts. The first part regards to Coastal Hydrodynamics and includes concepts of linear theory, tidal waves, wave generation and propagation, coastal processes and wave statistics. The second part concerns to coastal morphodynamics and include characterization of sediment transport and beach dynamics. The third part concerns to coastal and maritime structures, including types of maritime structures, coastal management and design of coastal and maritime structures.

The course consists of a set of theoretical-practical classes, in which the students become familiar with basic principles, from aspects related to management concepts to design, construction, monitoring and maintenance of maritime structures, exactly as in the case of FCT/UNL. Thus, students acquire the necessary technical and scientific bases that allow them to identify basic principles of wave transformation and propagation, he dynamic processes that occur at the coast and its characteristics parameters. These elements are the basis for maritime and coastal structures design and coastal management. The signature includes a 3 hours laboratory exercise, demanding a 9 hours dedication of the students and a 4 hours visit to a case study.

2.3 CCMM, Cadiz

The Coastal Engineering course is included in the third year of the Sea Sciences degree (CCMM in Spanish) at the Faculty of Marine and Environmental Sciences in Puerto Real (Cadiz, Spain). The degree in Sea Sciences is focused on students who intend to have multidisciplinary training. Therefore, subjects based on mathematics, statistics, chemistry, applied physics, biology, geology and other subjects related to environmental technologies are included in the students' performance. However, there is a lack of engineering knowledge in the marine-terrestrial field, despite the fact that the province of Cadiz invests large amount of money on the coast [3], the beach [4], and dune system maintenance [5]. Hence, the Coastal Engineering course is aimed at the Sea Sciences students, providing them a basic engineering approach to the problems generated by waves and their possible solutions. The teaching modules are: basic hydrodynamics; small amplitude and Stokes waves; extreme wave analysis and spectral description; wave diffraction, reflection and refraction; sediment transport and wave breaking, numerical models and laboratory models; maritime works; and finally beach nourishment activities. Hence, as these activities are directly related to the solution of real problems, the Coastal Engineering course requires the students' active participation both in the classroom and outside of it.

During the last ten years, the ratio of students who quit or did not take the final exam in Coastal Engineering at the University of Cadiz was 1/4 of the total number of enrolled students. Furthermore, the ratio of students who did not pass the final examination was more than 1/3. Therefore, only approximately 1/2 of the total number of students successfully passed the exam.

3 METHODOLOGY

3.1 FCT/UNL, Lisboa

The teaching and evaluation methodologies allow students to obtain not only knowledge at theoretical level, but also at practical level, being in agreement with the proposed objectives. It promotes interaction between students and teacher, since it follows a continuous evaluation model. Practical works allow for the students to apply theoretical concepts and deepen insight the thematic and get contact with reality, promoting at the same time team work spirit. The existence of tests for the

assessment of acquired knowledge promotes dialogue with the teacher due to accompanied study and by the support in solving questions.

Before each lesson the students have access online to documentation, specifically prepared for the classes, allowing students to study the matter with anticipation as well as to take notes during the class. In order to illustrate the subjects of the class, videos of case studies are included in the classes, if opportune. The assessment of the acquired knowledge has several components: three written tests, with a weight of 40%, 30% and 30% respectively, or a final exam. An oral evaluation is performed in case of marks above 16/20.

3.2 Fing/UdelaR, Montevideo

The teaching and evaluation methodologies, as in FCT/UNL, allow students to obtain not only knowledge at theoretical level, but also at practical level obtained from the laboratory experience and on the visit to a real case study.

The evaluation of the course is made by two parts: a project, a report of the laboratory experience and a final exam. The students can only apply for a final exam after approving the project and the report of the laboratory experience. The project, where the students apply the theoretical knowledge given during the course for a particular case study, includes a final report and it is expected to need for a 25 hours of dedication.

3.3 CCMM, Cadiz

Despite the lack of funds to support the Spanish Universities in the last years, some procedures have been implemented within the Engineering courses to decrease academic failure. For instance, though physical phenomena are ubiquitous in Nature, their study could become tedious –or simply indifferent– for young students when it is approached in a formal way. In contrast, the study of principles and laws of Physics can develop all its attractiveness and interest when they are also shown from a more entertaining and closer scope [6].

To enhance student interest and engagement towards the subject, a learning method based on encouraging students through the ability to increase their final grades by 10% was implemented. This procedure suggested that students complete some of the exercises at home each week. This homework should have a similar duration to that of the theoretical lessons, i.e., two hours a week. These assignments are not mandatory, but provide the opportunity to study and assimilate the subject concurrently with the theoretical classes. They are focused on the need for a continuous effort and personalised monitoring, as autonomous learning requires. Weekly homework is directly related to the main aspects of the theoretical lessons, and practical exercises as well as research of particular cases about the topics explained in class. During the class that follows, any possible question based on the exercises is explained.

This methodology, implemented for the first time in the course 2012-2013, allows the students not only to increase their knowledge of the subject because of their motivation to possibly improve their grades, but also allows the university and the professor to apply some transversal competencies within the subject. So far, this is not commonly done, but is enormously useful when the aim is to ensure the students' training in those skills to be used throughout their undergraduate studies.

For approximately a decade, the support of information and communication technologies (ICT) within the European schools and universities is one of the priorities of government education policy. This policy has been stimulated and guided by the e-Europe action for the development of an information society (more information in http://ec.europa.eu/education/policy/higher-education/), and particularly by the eLearning program, adopted at the Lisbon meeting in 2000 by the European Union [7].

By using ICT, the professor has the ability to add new teaching materials to enhance the comprehension and study of the subject; while students are able to check their learning progress, learn complementary concepts of scientific research by using e-databases, introduce themselves to e-learning, as well as refresh and update the theoretical concepts provided during the live lectures [8]. As a result, one of the goals of the EHEA (European High Education Area, http://www.ehea.info/) is achieved: getting students more autonomous after their educational experience.

4 RESULTS

4.1 FCT/UNL, Lisboa

The number of students enrolled at the IFP course at FCT/UNL was initially limited, as referred before. After 2011, the course was opened to the integrated Master of Science and the maximum number of students was increased. The number of students enrolled and approved, as well as the number of students that attended the exam are presented in Table 1 and Fig. 1.

Table 1 – Number of students enrolled and approved in IFP at FCT/UNL (Portugal)

IFP	Continuous evaluation		Exam	
	Enrolled	Approved	Enrolled	Approved
2010/2011	13	11	0	0
2011/2012	80	75	0	0
2012/2013	61	52	0	0
2013/2014	78	66	4	4

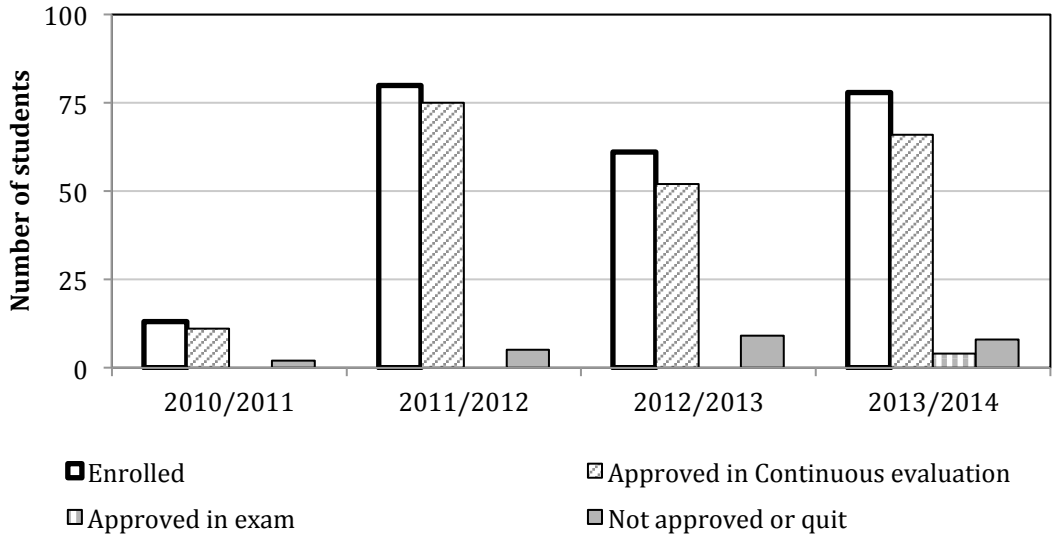

Fig. 1 – Number of students enrolled, approved and not approved or that quit in Railways and Ports Infrastructures at FCT/UNL (Portugal)

4.2 Fing/UdelaR, Montevideo

The number of students enrolled and approved in recent years is available on Table 2

Table 2: Students enrolled and approved in Fing/UdelaR (Montevideo) in the time interval 2007-2013

		Continuous evaluation		Final Exam	
		Enrolled	Approved	Enrolled	Approved
Marine Hydraulics	2007	4	3	4	4
Coastal and Marine Hydraulics	2010	3	3	0	0
	2011	4	3	2	2
	2012	1	1	6	4
	2013	4	4	6	5

4.3 CCMM, Cadiz

Similar data to those presented for Lisbon and Montevideo are showed in Table 3.

Table 3. Number and percentage of students who failed and passed the final exam in the subject of Coastal Engineering from 2007 to 2013 in Cadiz.

Academic year	Enrolled students	Quit	% Quit	Fails (D)	% Fails	Total Pass	%Total Pass
2007-2008	140	19	13,5	26	18,6	95	67,9
2008-2009	211	12	5,7	122	57,8	77	36,5
2009-2010	122	12	9,8	70	57,4	40	32,8
2010-2011	142	16	11,2	42	29,6	84	59,2
2011-2012	121	20	16,5	17	14,1	84	69,4
2012-2013	47	5	10,6	1	2,1	41	87,2

5 DISCUSSION

The number of students enrolled and approved (and the rate between both of them) in each University is presented in Table 4, making possible to compare the results of the three universities.

First of all, the different number of students enrolled in the 3 universities must be taken into account. For instance, the number of students in Montevideo is an order of magnitude less than those enrolled in Lisbon and Cadiz. Evolution of the number of students enrolled in classes related to Port and Coastal Engineering is showed in Figure 2. However, and contrary to what might seem a priori, it is interesting to note that there is not a direct relationship between the number of students enrolled and the number of students who fail the subject, since all Universities have similar results in % of students approved.

Table 4 Number of students enrolled and approved in Montevideo, Lisbon and Cadiz Universities

	Montevideo			**Lisboa**			**Cadiz**		
	Enrolled	**Pass**	**% Pass**	**Enrolled**	**Pass**	**% Pass**	**Enrolled**	**Pass**	**% Pass**
2010-2011	3	3	100,0	13	11	84,6	142	84	59,2
2011-2012	6	5	83,3	80	75	93,8	121	84	69,4
2012-2013	7	5	71,4	61	52	85,2	47	41	87,2
2013-2014	10	9	90,0	78	66	84,6	50	47	94
Average	6,5	5,5	86,2	58,0	51,0	87,1	90,0	64,0	77,5
St. Dev.	2,9	2,5	12,0	31,2	28,3	4,5	48,7	23,2	16,0

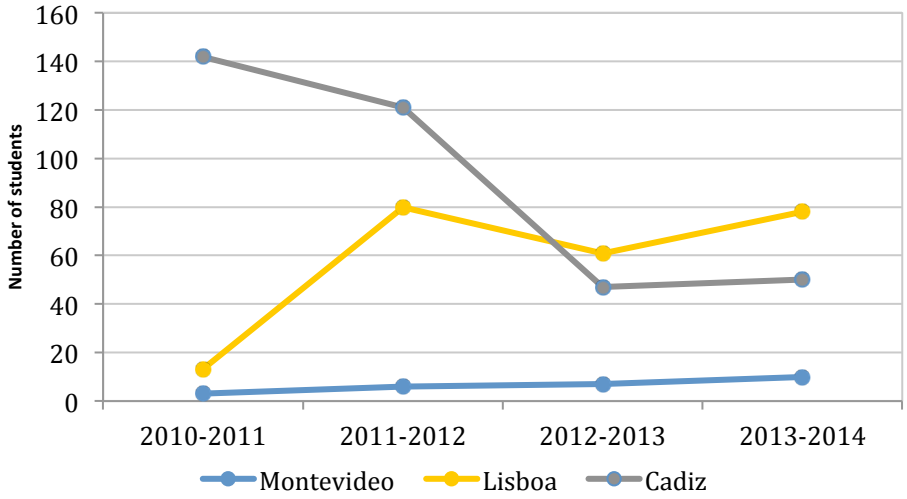

Figure 2 - Evolution of the number of students enrolled in classes related to Port and Coastal Engineering in Montevideo, Cadiz and Lisbon.

Effectively, as can be seen in Fig. 3, the percentage of students who pass the course is very similar in the 3 universities when the continuous evaluation is adopted. This percentage is never less than 70%, ranging on average between 80 and 90%. As already referred, this type of evaluation was not implemented in Cadiz until the year 2012-2013.

Another point to note is that the standard deviation between the qualifications in the three countries is not large, being less in Lisbon (4.5%), following Montevideo (12%). The highest value is obviously in Cadiz (16%), because the continuous evaluation was implemented later. In Lisbon the evaluation was always by continuous assessment. This can be the reason that there are only few or none students for exam evaluation in this course in FCT/UNL. In fact, almost all the students, more than 85%, are approved before exam period, i.e.: continuous evaluation was chosen.

Audiovisual resources were also proved useful to improve the teaching of coastal engineering and therefore such initiatives should continue to encourage the students' interest. In Cadiz, videos explaining the lessons have provided an appropriate material to students, who, due to diverse circumstances, cannot attend regular classes, e.g., students living abroad or students whose schedules do not fit with the official timetable [8].

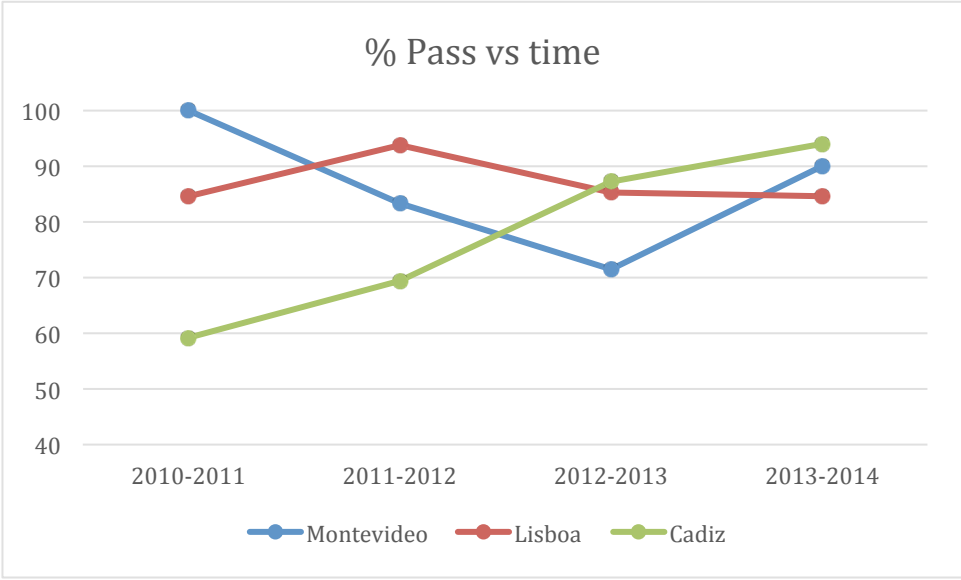

Figure 3 Percentage of students who pass the Port and Coastal Engineering course in the universities of Montevideo, Lisbon and Cadiz

6 CONCLUSION

In this paper, a comparison is presented among the methodologies used in 3 Universities of different countries: Montevideo (Uruguay), Lisbon (Portugal) and Cadiz (Spain). Furthermore, changes experienced in the courses are discussed herein by comparing the percentage of success in the different locations. Moreover, influence of the different methodologies and the possible reasons for these changes are also presented and analysed.

In general, application of continuous evaluation has brought a decrease in the number of students who abandon or quit the classes. In addition, an increase in the percentage of students who pass has been noticed together with an improvement of their grades, except at FCT/UNL, at Lisbon, where the results have remained stable.

As a conclusion, the improvement in educational outcomes has been achieved through the concurrence of different factors: the existence of more frequent written and/or oral exams, practical examples of case studies as well as access to specific tools of new technology and to documentation specifically prepared for the classes and available online [8].

Complete dedication of the students was achieved by applying a feedback method through coursework or homework tasks. In all the Universities compared herein, the application of this procedure lead to a high percentage of the students that successfully pass the final exam and obtaining better marks [9]. Furthermore, the ones that passed the subject obtained better marks.

Evidently, the above mentioned tasks require a strong commitment and great effort by the teaching staff. If human resources diminish, as it is happening in Spain and Portugal due to the budget reduction in education [10], two difficult questions arise: For how long will teachers' current effort be maintained? What impact will their complete devotion to teaching have in their research performance?

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