Learning engineering by teaching engineering in the European Higher Education Area.

Video engineering approach.

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Abstract— **Even though active learning is not a new trend in engineering education, different schemes based in "learning by doing" are being proposed every day in the engineering education community. Considering "teaching" a topic to be a learning activity it can provide profound learning outcomes. A course previously adapted into an active learning environment has been reshaped to let the teaching experience to take place as a learning situation.**

Keywords-active learning; learning by teching; engineering education.

I. Introduction

The arrival of the European Higher Education Area and the re-design of University degrees have become a big challenge. The new degrees will start their implementation in September 2010 at the University of Alicante. Even though there are experiences in which competences-based education is a reality, the uncertainty feeling is inevitable. In this environment, engineering teaching-learning strategies are immersed in a constant evolution worldwide. The case of European Universities is especially noticeable due to this convergence process. The main goal of our task as educators is to provide with students an environment in which learning may happen. The active role of students is now a must to reach the new quality standards. Even though active learning is not a new trend in engineering education, different schemes based in "learning by doing" are being proposed every day in the engineering education community. There is no doubt about the benefits of "doing" as an effective learning tool applied to engineering training. Nevertheless, by itself, doing can not ensure effective learning to take place. A further reflection of what and why has been done is compulsory to transform the information into knowledge. In fact, there are several "doing situations" in which learning appear to be more exhaustive. Let us think, for instance, in the learning outcomes derive from our own teaching experience.

Teaching a new topic, or course, for the very first time is a profound learning situation. Any educator will agree considering her or his first classes as a high-level learning situation. Besides, within this teaching environment, assessment provides a valuable generation of feedback and reflection. Making students be involved in such an environment (peer-teaching and peer-assessing) will let them into a favorable and very effective learning opportunity for both trainer and trainee.

With these principles in mind, a course previously adapted into an active learning environment has been reshaped to let the teaching experience take place as a learning situation. Course activities try to persuade that some of the students will act, at certain moments, as trainers of a group of colleagues being trainees. Roles will change at different activity stages so that all students will have to be the trainer sometime.

Regarding the assessment, students will have the opportunity of getting feedback and high level reflection about the concerning subjects by means of peer and self assessment.

Besides, working in a particular course designed into an active learning environment, including learning by teaching will get not only academic but transversal skills improvement. Issues as group working, communication skills or liability are managed as good as engineering or scientific skills.

After a five-year process of adaptation of the learning model concerning the courses "Video Engineering" and "Video Laboratory" from conventional to active style, a considerable set of activities have been generated. Both courses present high realistic engineering contents, making them an interesting environment of professional-like engineering training experience.

Although Video Engineering and Video Laboratory are third year courses in Telecommunication Technical Engineering (BSC), single or sequences of activities have been exported to other compulsory and optional courses inside both Telecommunication and Computer Science degrees. The possibility of exporting any particular activity or sequence of activities to other disciplines will provide a wider range of benefits, promoting improvement in these other courses. This process has been carried out to provide other professors an easy way to adapt one particular activity or a sequence of activities focused in Video Engineering to their own disciplines. One of the main outcomes of the project was the interchange of activities between courses trying to make extensive the application of the methodologies designed.

II. Teaching situations

Video Engineering is a third year course in Telecommunication Technical Engineering (BSC), with sound and image speciality. It is a compulsory course included in two of the three program branches considered at the syllabus. The duration of the course, as established at the curriculum, is six theory credits and three practical ones, with one credit considered as ten hours attending class. Video engineering is a discipline with a high degree of engineering based development. The course main goal is formulated by one general objective: to train engineering work characteristics by means of studying video systems. Some of the competences explicitly presented include group working, communication skills and complex problem analysis. For that reason, it can be suitable for using problem based learning (PBL) [1] boarding the different aspects as if the students were the engineers trying to find the answer of a particular technology problem. This will be the approach of all activities performed along the course, taking into account the constraint of slowly increase their level of complexity. Besides, a series of short research projects is included within the course, resulting in a methodology combining project [2] and problem based learning. A more comprehensive course description can be read in [3].

Summarizing, the course is structured into an active learning scheme. Nevertheless, if students' degree of motivation is not high enough it is not easy to maintain the required working level to success in the course. An interesting strategy to let students reach a high level of motivation can be found in the "ripples model" presented in [4]. This model states the main factors and their relationships underpinning true learning situations. These five factors can be declared as: 1. wanting to learn, 2. needing to learn, 3. learning by doing, 4. learning through feedback and 5. making sense of what have been learned. Teaching a new subject is, among others, an experience in which all five factors are present, so it can be assumed to be a true learning situation.

The adaptation of Video Engineering course into an active learning scheme began in 2003 with a pilot test. Since that time a continuous evolution have been carried on, introducing changes in course structure, contents, methodology and assessment. From 2005 the course can be considered to be fully implemented into an active learning scheme based on cooperative learning, problem based learning and project based learning. Students are organised in small working groups, performing a sequence of activities preceded by short introductions and followed by discussion facilitated by the professor. With this starting point, it is not difficult to reshape some of the activities with the aim of making teaching a conscious part of the course.

The project hypothesis can be stated as: "making students play teacher's role puts them actively in a "wanting and needing to learn" situation based on a high degree of motivation". Some measurable results of this motivation are expected in terms of improvement of the academic results and reduction of the number of drop-outs, as these two items are widely considered as some intrinsic problems in engineering education [5]. Even though Learning by Teaching is not a new trend in education, it has been basically used in language learning [6], [7]. The goal of this work is not to get an adaptation of previous learning by teaching schemes to engineering education, but to emphasize teaching opportunities in an engineering course adapted following active learning models.

It is important to state that all the referred teaching situations are preceded by a working stage following the designed sequence of activities. We are not making students just to explain part of the syllabus to the others. All the teaching situations follow a previous reflection stage ensuring the expected learning outcomes.

The following sub-sections will describe some of the learning situations generated in the course. The goal is not to make a comprehensive description, but to present the basic ideas supporting the teaching-related activities.

A. *Course goals statement*

If one wants students to feel responsible of their learning process, they really have to be responsible. The first designed activity of the course is performed to let students to state course goals. If students are working what and how they want to, motivation is guaranteed.

B. *Explaining contents*

Group working activities lead easily to explaining-related situations. Taking into account some basic rules of cooperative learning will ensure that, at specific moments, all group members will have to act as teachers explaining their group-mates part of the course contents.

Besides, the project based sections of the course facilitates a major challenge, making students to explain their research results to the remainder of the group (Fig. 1).

Figure 1. Student presenting research results to the remainder of the group.

C. *Tutorizing laboratory work*

Laboratory work in video engineering is not easy to organize. The laboratory is equipped with broadcast-quality video production elements representing realistic professional

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working configurations. Due to the high cost of the laboratory equipment, there is only one working station of each configuration, so each cooperative group is working in a different station. Every week, each group has to be able to become familiar with a different, new and unknown working station. Having up to 12 groups trying to figure out how a new, and different for each group, system works can be difficult to manage. To avoid this situation to become chaotic, some students act as tutors of any configuration (Fig. 2). Each group has had extra time at the beginning of the semester to become experts of one of the available working stations. This system generates benefits in two ways. Not only students are teaching mutually, but the problems of the groups can be solved more eficently.

The system is implemented so all the students will have to play tutor's role during course semester.

Figure 2. Student playing the role of peer-tutor.

D. *Assessing*

Possibly, the activity demanding a higher level of responsibility is the assessment. Having to assess some other's work implies a profound knowing of the matter and a serious stage of the "learning by feedback" and "making sense" ripples presented earlier in this section. Students will have to perform peer and self assessment activities at different course stages.

III. RESULTS

Course design results are measured using both quantitative and qualitative indicators. Quantitative indicators are the students' academic results summarized in their final marks and the analysis of the number of passing and abandoning students through the course. Qualitative analysis is based upon questionnaires designed to get students' opinion regarding different course aspects.

Fig. 3 presents the evolution of the average final mark of the whole group from 2002 since 2008 and its standard deviation.

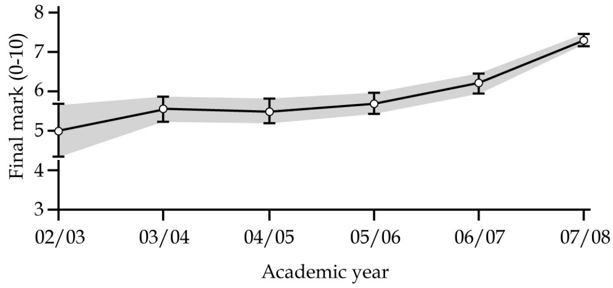

Figure 3. Evolution of the average final mark in a 0-10 scale and the standard deviation between 2002 and 2008.

As the course methodology has been changing, assessment has been evolving as well. The assessment is actually performed as a combination of several evaluation activities combining self, group and peer assessment and a final exam. A more detailed description of the assessment procedure can be found in [8].

This analysis period has been chosen as in 2002 the course was still implemented in a conventional methodology based on lectures, laboratory and problem solving sessions. The first pilot experience of active learning approach was carried out in 2003, and the teaching-based activities were introduced in 2007.

The results derived from Fig. 3 are quite interesting, as they show a clear ascent tendency, from 5 to 6.9 points in a 0-10 scale. It is also significant that the standard deviation decreases as the average value increases, meaning not only an improvement on the academic results but also a more coherence between students.

There is no direct indicator to measure if the introduction of teaching activities has impact in the motivation of students. Nevertheless, thinking of motivation as an effect of the "wanting to learn" and "needing to learn" ripples, a relationship can be assumed to be between the presence of that ripples and the number of students abandoning the course. An increase of the degree of "needing" and "wanting" ripples will cause a decrease of the drop-outs. Fig. 4 presents the evolution of the number of abandoning and passing students in the analyzed period. It is remarkable the difference in figures between the first year (traditional teaching scheme) and the other ones. In 2002 the number of abandons was near to 50% of the students. On following years this figure clearly drops below 20%, surprisingly arriving to 0% on 2007.

Moreover, the conclusive data about drop-outs is followed by an ascent slope passing students curve, going from 60% to more than 85%.

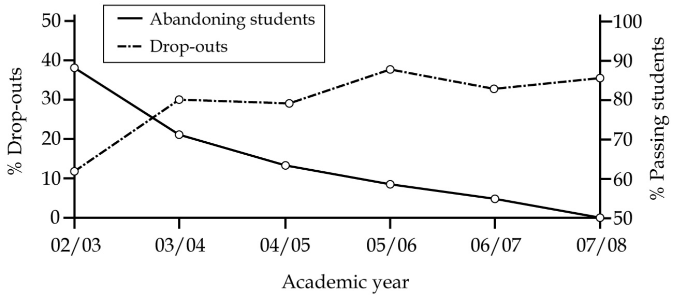

Figure 4. Evolution of number of drop-outs (left axis) and nunber of passing students (right axis) between 2002 and 2008.

Besides the numerical results, some qualitative data have been obtained using custom designed questionnaires. The aim of such questionnaires is to get students' opinion concerning particular aspects of course structure, such us contents, general methodology, group working tasks, and so on.

The questionnaire is composed of a set of sentences that students have to mark their degree of acceptance. The answer is coded in a 0-5 scale, in which 0 means "absolutely in disagreement" and 5 "absolutely in agreement". One of these sentences that students may (or not) agree with states "I have the impression of being learning", relating to the self awareness of the learning process. Fig. 5 shows the mean value of the answers to this sentence in the 0-5 scale previously presented. The degree of agreement with this sentence is especially significant, as it relates, not only with students' responsibility towards learning, but with being actively conscious of the learning outcomes derived from a particular set of activities.

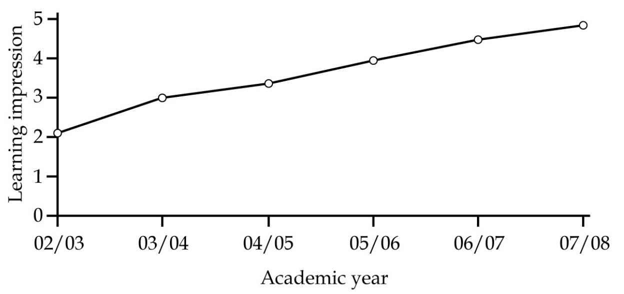

Figure 5. Evolution of the mean value about "I have the impression of being learniong" sentence between 2002 and 2008.

The full questionnaire consists in 25 coded questions plus five more open answer questions to let students freely express their opinion about the course. Fig. 6 presents the mean value of the 25 questions, rounded in 0.5 steps, regarding 2007/2008 course.

The topics included in the questionnaire are both general and specific ones about different course aspects (goals, contents, methodology, assessment…). Without pretending to perform a highly detailed analysis of the results, it is clear that students' general opinion about the course is quite positive. As the questionnaire has been designed just for Video Engineering course, it is not possible to compare results with other courses. Notwithstanding, it can be said that the general results have been improving following course evolution.

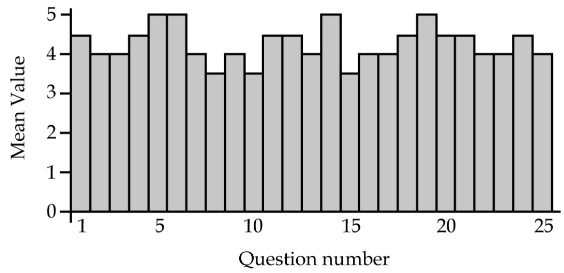

Figure 6. Mean value of the answers to the course evaluation questionnaire regarding 2007/2008 course.

Considered as another interesting outcome, the possibility of exporting any particular activity or sequence of activities to other disciplines will provide a wider range of benefits, promoting improvement in these other courses. The methodology adaptation process carried out in the Video Engineering course during the last four years has generated a considerable amount of single activity and sequences of activities. Up to date, the activity migration process takes place unidirectionally, from Video Engineering to other courses. This fact is due to having in mind the possibility of migration as one of the design basis. The courses actually using activities from Video Engineering are Digital Electronics (firs year compulsory course in Telecommunication Technical Engineering), Broadcast and Cable Television (third year optional course in Telecommunication Technical Engineering) and Multimedia Techniques (third year optional course in Computer Science).

In addition, as a final quality indicator, a test was performed by the end of the first semester in the 2007/2008 academic year in a randomly selected last year course of the degree. The random aspect was included to unlink the answer of the test with any particular course. Students were asked to write down the two courses in which they had the impression of being learned more. There were two most rated courses selected clearly among the others, with similar marks. One of these courses was Video Engineering, while the other is one of the courses actually adapting some of the sets of activities designed for video engineering.

IV. Conclusion and Future Work

Active learning schemes are widely considered as suitable methods to be used in engineering education. Nevertheless, it is possible to improve the results of the learning process going further than just "making students to do things". Complementing the "doing" factor with elements ensuring that students are conscious of their own learning process (they have evidences of how they are learning) improves course outcomes. One of these factors is the promotion of teaching experiences to students.

Teaching related activities are well shaped to provide the wanting and needing to learn ripples that will generate a high level of motivation and self awareness of learning in students.

From the basis of a course designed following an active learning scheme, it is simple to introduce small changes allowing teaching opportunities to take place explicitly.

The analysis of quantitative figures obtained from students marks and qualitative data obtained by questionnaires, are coherent with the expected results. The presented scheme clearly improves motivation and promotes students to be conscious of being learning.

There is one more indicator not still implemented to analyze the impact of course design concerning professional skills demanded by audiovisual industry. A set of contacts have been done with selected professionals actually enrolled in several TV and video production facilities. They will be asked about their opinion concerning the relevance of the skills obtained by students related with real industry needs of the video engineer position.

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