AN EXPERIENCE TOWARDS THE ECTS MODEL IN ELECTRONIC TECHNOLOGY USING ACTIVE LEARNING TECHNIQUES

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Abstract

The change of the Spanish University system following the European Credit Transfer and Accumulation System (ECTS) is imminent. This brings the need of a change of orientation in lectures, and the adaptation of former teaching methodologies into different active learning based ones. In this frame, this work presents the gradual transformation of three subjects taught in the Faculty of Computer Science of the University of Murcia, Spain. Main pitfalls of the process and the results achieved after years of using active learning techniques are shown in the paper.

Keywords - Innovation Active Learning, Collaborative and Problem-based Learning, European Higher Education Area.

1 INTRODUCTION

Spanish university is into a converging process towards the European Higher Education Area (EHEA) and the European Credit Transfer and Accumulation System (ECTS). In this context, diverse teaching techniques play an important role in education, making the migration process easier to adapt current degrees to new European regulations and guidelines. These principles have been created with the aim of assuring the quality of higher education.

Despite the fact that new changes in the university teaching process focus on improving the results of the students, the application of concrete actions cannot come along, and must be complemented by means of measurements that point the current problem of lack of motivation. Obviously, the personality of the lecturer affects her or his lectures, but it is also true that some changes in the methodology may help the undergraduate to follow the subject. In this line, content management systems and virtual teaching are more and more applied, thanks to the expansion of Internet. These systems allow the management of the contents of subjects, along with discussion panels, announcements and even exams through the web.

Most of the faculties of the University of Murcia are joining experimental initiatives in search of European convergence since the year 2005.This process aims at the gradual adaptation of a teaching system compatible with the EHEA. The faculty of Computer Science has been involved in the process from the beginning, starting in 2005 a pilot project where three degrees (Graduate in Computer Science, branch Systems, Graduate in Computer Science, branch Management, and Engineer in Computer Science) considered new EHEA concepts. In academic year 2006/2007 same line was followed, and three new subjects introduced new teaching methodologies adapted to the EHEA. Last year, 2007/2008, the adaptation of the process became massive.

However, the adaptation of one subject to the EHEA, and the application of new teaching techniques demand important efforts from the side of the lectures. Lecturers must cope with the adaptation to new methodologies and the consequent tuning, keeping a balance between quality and material and human resources. As a matter of fact, not all the methodologies are applicable when the number of students per class is large.

Different active learning methodologies have been considered in a wide range of study cases [1], with the aim of integrating undergraduates in the learning process. In this way, the classical point of view, based on teaching different topics in lectures, is now criticized, and the teaching community has gradually started to take into account the student participation.

Cooperative learning plays an important role in this field [2], as an active methodology. With it, students work in groups, which stimulate the members to work in all the tasks of a project. The answer to the problem has to be found by the "Team" [3], what is a key point for future professionals. This is a very important idea in engineering teaching, but it has not been applied too much yet (mainly in practical lessons with limited resources in most of the cases). Precisely, in engineering studies, the use of a methodology that follows this idea, as it is considered Problem Based Learning (PBL) [4], has been crucial to implant these concepts. Some applications of PBL can be found, for instance, in computer science studies [5,6].

This paper shows the gradual transformation of lectures in the Electronic Technology field, within computer science studies, during the last years, by means of a set of pilot projects towards the European convergence, which have been applied in the different courses. Cooperative learning and problem based learning techniques have been applied in two subjects, observing the trend in the number of students who passed the evaluation, but also noting their attitude.

In this paper main deficiencies of the classical teaching model in engineering lectures are analyzed and the different solutions adopted to solve these difficulties are specially addressed. This work also presents several particularities of the learning methodologies and evaluation processes applied in each subject. It is expected that this work serves as a guide for future experiences in similar cases, where the application of cooperative learning must be introduced in a short period.

Nowadays, our subjects object of study are ECTS compliant, and they are managed by an e-learning platform, powered by Moodle [7], in order to make easier the application of the aforementioned learning methodologies. This software, and other similar tools, allows an exhaustive monitoring of each student and it is a useful tool to maintain a communication means, not only between teacher and students, but also among students themselves.

Several evaluation results about students enrolled in the subjects under consideration in the last four years have been collected. These results clearly show the improvement (especially in the first course) during the years that the active methodologies have been applied. Moreover, this methodology enables the teacher to maintain a high level of knowledge of the subject, something not represented in the empirical results.

The rest of the article is organized like this: Section 2 presents a description of the teaching methodologies for each subject under consideration; Section 3 analyzes the results obtained by the students in these subjects; Section 4 focuses on the pitfalls of the transformation process to these new learning techniques, and finally, Section 5 concludes the paper.

2 TEACHING METHODOLOGIES

This Section describes the methodologies that were adopted in each subject object of the study presented in this paper.

2.1 Technology and Electronic Systems

Subject "Technology and Electronic Systems" belongs to the second semester of the first year of the degree Computer Science Engineer (5 years). It is a mandatory subject that presents to the students concepts of electronics that will be required to understand future subjects. There is an important presence of practical lectures (around 40%). Undergraduates of this subject study basic concepts of electronics. At the end of the semester, students will be capable to identify different devices and circuits, solving problems with circuits, and they will know how to use tools to identify, simulate and implement these circuits. The teaching guide of the subject [8] shows its corresponding transverse abilities and formative objectives.

We decided to implant some active learning methodologies, mainly based on specific and continuous monitoring for every student. Additionally, collaborative work has been encouraged.

Main motivation for the adaptation of active learning methodologies was the poor results achieved in almost every subject of the first year of the degree of Computer Science Engineer, by means of following the most common classic methodologies based on master classes and final exams at the end of each semester.

Main problems detected on this subject were:

- Due to the fact that there was only a final exam, students did not study weekly, but only few days before the exam, at the end of the semester.
- As a consequence of this lack of weekly work, and due to the fact that most of chapters were based on previous ones, students assimilate worse and worse new concepts until some of them finally stop attending lectures.
- Finally, practical lessons were not very productive, because students were not familiar with theoretical concepts to be applied in practice. It was found that students learn by heart some procedures without understanding what they were really doing.

In the frame of the adaptation process to the EHEA of the University of Murcia, we decided to change this unsatisfactory process, with the support of our institution. New active learning techniques were applied with the objective to improve the performance and the knowledge of the students of this subject.

An active learning methodology based on Information and Communication Technologies (ICT) was decided. The e-learning Moodle platform was finally chosen. This platform eases the management of on-line resources, and supplies to the lecturer a significant help for individual monitoring of the students work. Main features of the system are:

- Simple and intuitive organization of the resources needed for each chapter or didactic unit: theoretical documentation, slides, movies for practising, supporting homework, evaluations and self-evaluation, etc.
- This platform allows the students to monitor their own learning though the semester, obtaining marks just after each activity carried out.
- It makes easier the work of continuous assessment, by means of the management of marks for each activity carried out by the students. Individual and group statistics are easily available, and there is a number of tools to prepare activities, such as self-assessments based on questionnaires, learning activities based on crosswords, hot potatoes, etc.

During the last academic year, and in frames of the pilot program, the lecturer introduces first day the weekly plan of the subject. This plan includes master classes, problems, practical lectures, evaluations, tutorships and hours of study. The assessment system is presented and the students are informed about the possibility to apply only for a final exam (on the official date).

The number of master classes of the subject was shortened, paying now special attention to the most relevant parts of the contents (contrary to the former method in which every specific chapter was explained one after another). In addition to that, and apart from the official tutorship hours, some time is allowed in the end of each lecture for questions and doubts of that day’s lecture or previous one.

During practical lessons, teams of three students are created, what helps to solve problems in group. Lecturer briefly introduces the problem, and students can use documentation, notes, movies, etc. to solve the problem under consideration at its due time.

Just after finishing all the activities of one chapter, the assessment is carried out by means of Moodle. A test with theoretical questions and problems is accessible only after the students have scored in a number of self-assessment activities available for them.

Seven chapters that are independently evaluated make up the whole subject. Final mark will be the mean value of these seven marks. There is no condition of minimum mark for each chapter, and according to our statistics, there is never a big difference between obtained results from one chapter to another.

The attendance to theoretical lessons is not mandatory, but students must follow at least 80% of practical lectures. Verifying this does not increase the mark, but avoids an additional exam about practical contents of the subject. Normally, all the students that follow the continuous assessment system attend lectures regularly.

Marks of every chapter are obtained by using Moodle in a controlled classroom equipped with computers. No additional materials are accessible this time. Complementary activities bring the possibility to the students of obtaining an extra point (evaluation is from 0 till 10). These activities consist of self-assessments and self-learning activities. These activities are available at least one week before chapter’s evaluation, and must be finished before the latter. Students are forced to do at least one self-assessment before real evaluation. This is a good way how to train for it. During self-assessment, all materials are available, and students can be connected anywhere. However, they must bear in mind that they'll have same time for both evaluations.

Moodle provides results of evaluations immediately, what encourages students to plan future evaluations according their mean values.

2.2 Embedded Systems

This subject is obligatory for students, and places in the third year of the degree Graduate in Computer Science, branch Systems. There is no threshold for number of attendees, what makes more difficult the adoption of EHEA in general and, more concretely, problem based learning (PBL).

Contents of this subject are very general, and they include some issues that should have been learnt in previous subjects. In the student guide [8] the estimated hours of students' work, ECTS credits and gained abilities are detailed.

After two years of adaptation to the new methodology, this subject has changed significantly. Initially, master classes were completed with several sessions in the laboratory. However, final exam was mainly the only system for evaluation. In order to improve the learning process, we decided to complement this approach with the possibility of preparing an optional work connected to the topics of the subject. However, despite the fact that the mark obtained by doing that work was directly added to the final mark, only a few students were eager to participate in this initiative.

During the last two years, some changes were done in the subject in the line of a PBL approach. Whilst master classes are still there, students who attend the lessons are rewarded, and practical lectures are divided in a set of attendance lectures plus a final project. The set of practical reports are delivered by the students along with the project.

There is a fully equipped laboratory of electronics available for practical and project sessions. Multi-meter, oscilloscope, wave generator, power sources, computer and hardware board with microcontrollers are also available, along with Internet connection and media means. This brings some help in the process of adapting new techniques.

Final evaluation is itemized like this:

- 10% attendance to theoretical classes.
- 40% final theory exam.
- 15% laboratory sessions.
- 35% final project, what includes the developed software, its report, and the public defense in front of the lecturer:
  - Report: 50% (for the team)
  - Prototype: 30% (for the team)
  - Interview: 20% (individual)

As it can be seen, an important part of the mark is based on the report. This way we try to emphasize the importance of writing good reports, the most common way to show someone's work in a professional career (more than through prototypes, even if the product is finally carried out). Timely deliver of the reports of lab sessions are required to pass the subject. Additionally, a 40% of the maximum mark in final exam is also required.

There are some quality criteria for the presentation of the final project, that are described in the documentation provided to the students at the beginning of the semester. This quality factors are described in detail in [9], referred to another subject, Design based on Microprocessors, which is presented next.

2.3 Design based on Microprocessors

This subject also belongs to the third year of Graduate in Computer Science, branch Systems. There is a threshold of fifteen students per class. This number has been very helpful to include new teaching methodologies from the academic year 2004/2005.

Contents, ECTS credits and developed abilities can be found in [8]. This subject introduces the students into the design and programming of an embedded system. Basic concepts of computers already acquired by the students are the starting point of the subject, where commercial microcontrollers are explained.

Current methodology follows the PBL philosophy, which came along last four academic years. Initially, subject was taught following a standard system consisting of half time master classes, half time practical lessons in the laboratory. Evaluation was based on a minimum attendance to practical lessons, and the final exam corresponding to the theory contents of the subject.

First step was the suppression of the final exam, which left its place to a final work, whose result decided almost the whole evaluation of the subject. This way, students oriented better their own learning process. Although this method changed the approach of youngsters to the subject, two main pitfalls were detected. On the one hand, all the evaluation was dedicated to a final work, without any intermediate checkpoint. The consequence of this was that most of the students started to prepare this work on the very last days of the semester, with the obvious detriment on its quality. On the other hand, team work was not stimulated, even though students normally discussed their own approaches.

During the last year we incorporated new ideas based on PBL and team work, such as the list of deliverables and the initial presentation of a problem/project on which group of students must work. Master classes are constrained now to only first few chapters with basic concepts, what only takes a few hours. The rest of the subject consists of team work in and out the lab. The results of short practical sessions are reported by the students by means of deliverables that must be sharply stuck to deadlines in order to provide a clear temporization of tasks for students. Although our methodology demands that students realize each task, the regulation of the University obliges to give a chance of a final exam. Nevertheless, for today no one chose that option.

Moodle is used as a useful tool for the PBL system, what complements standard tutorship hours. Classroom presents no significant resources, while the lab is the same that is employed for the subject of embedded systems.

Evaluation goes like this:

- 25% presentation of at least 85% of individual deliverables.
- 15% attitude and participation. Attendance to class (theory and practice). Involment and leadership in teamwork.
- 60% project. This includes: developed software, report, and the public defense in front of the lecturer:
    - Report: 30% (for the team)
    - Prototype: 50% (for the team)
    - Interview: 20% (individual)

If a student presents the required number of deliverables, the rest of assessments are not demanded. If the mark of project defence is lower than a certain threshold, the subject is not passed. Presentation is made by the team, but the lecturer may address questions to any of the members.

Like in embedded systems, rules are explained to the students at the beginning of the semester.

3 ANALYSIS OF COLLECTED MARKS

As it can be seen in Figure 1, the consequence of the implantation of new methodologies brought a higher number of passed students in the subject of Technology and Electronic Systems. This graph shows the mark statistics obtained on June in past five years. Continuous assessment, team learning and the use of ICT for monitorization, implied more motivation from the students, what can be seen in the statistics of the last three years.

Paying attention to the data of Figure 1 we can obtain some conclusions. The difference between the number of students who applied and those who actually passed the subject became significantly smaller from the first year of application of ECTS methodologies. In the last year, both numbers are the same.

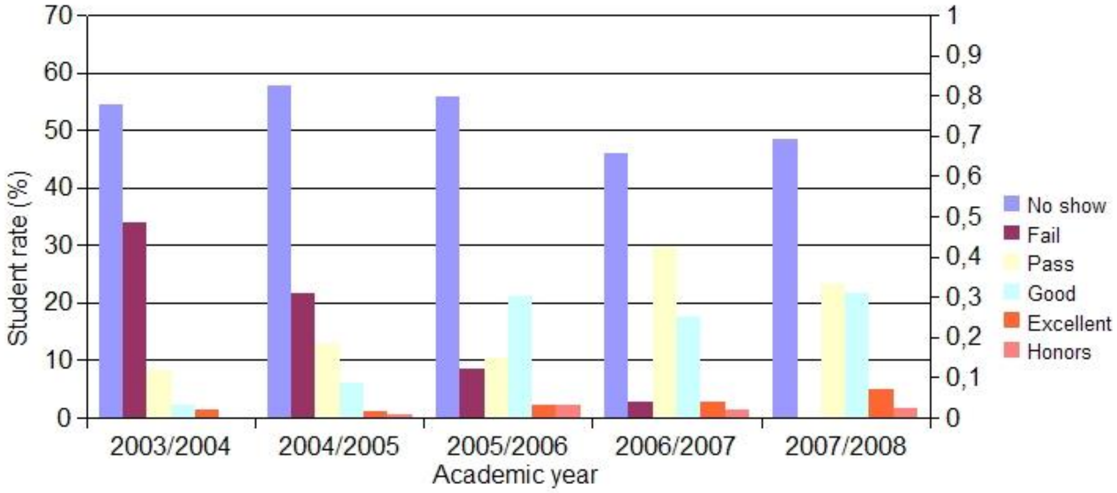

Fig.1. Results in Technology and Electronic Systems.

Students who applied only to first assessment (or none of them) were considered as no show. Therefore, an aspect to polish in the subject is the reduction of gap between students who apply to the subject, and those who finally follow the subject. We believe that most of these students are repeating the year, or working. Thus, another tool based on e-learning should be applied to make the subject more accessible in these cases.

Another important issue is the level of knowledge of undergraduates. In the year 2008, only 14 students obtained marks lower than 7 (over 10), while 31 passed the subject (5 points or more). 3 students got 9 or more and one 10 points. Let us remark here that the level demanded for passing the subject has been slightly increased during the years mentioned in this study.

On the other hand, Embedded Systems still presents a number of passed students. Nevertheless, mean values are noticeable better than in some main or mandatory subjects of this degree. Figure 2 shows these results on June for last three academic years. In 2005/2006 the high level demanded to pass the subject, and lower practical contents imply a remarkable number of applicants who fail to pass. Although practical contents were poor, they represented an overestimated part of the evaluation. For this reason, the overall assessment increased. The following year, 2006/2007 practical contents became higher, and a final project was added to the attendance sessions in the lab. New demands in the subject were not well taken by students. Project was eventually not considered in the final calculation of the mark, and was simply considered an extra task. Only a few students presented it. However, it was noticed that those students that who presented a project, even a not very good one, showed a better knowledge of laboratory sessions, which anyway required certain deliverables. In the theoretical part, the higher requirements were found to be the key to explain lower results in the overall assessment. For the year 2007/2008, it was considered to reward the attendance to theoretical lessons, and the description of the final project, obligatory for students this year, was clearly improved. Globally, not only the results, but also the knowledge of the subject became better.

The case of Design based on Microprocessors is quite different, due to the fact that this subject is optional and clearly practical. In addition to that, students are expected to be especially interested in this subject.

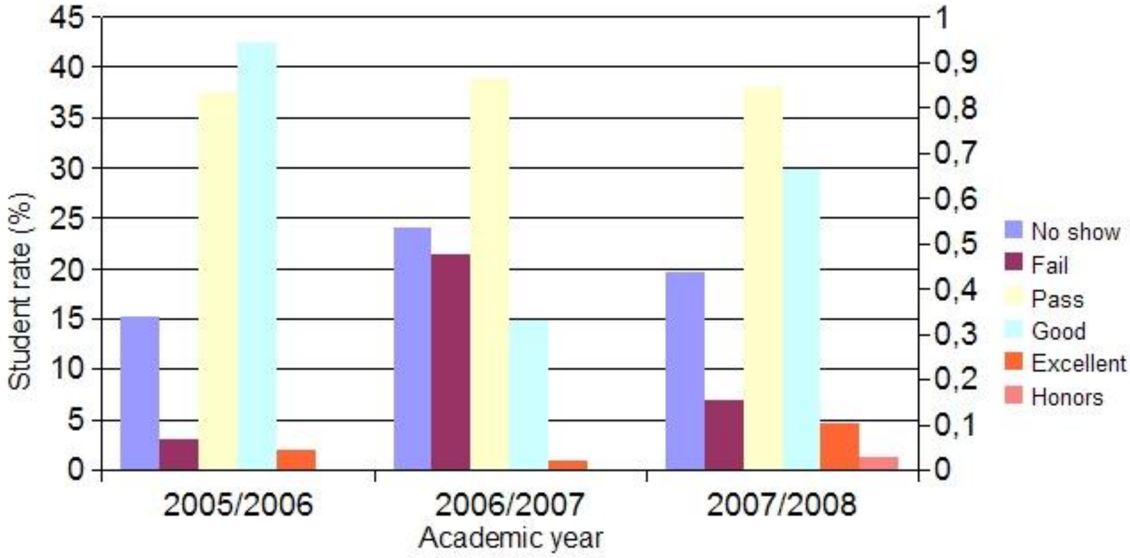

Fig.2. Results in Embedded Systems.

Figure 3 shows the results obtained in this subject in June during the last years. June appears to be more representative than September regarding “no shows”. As it is visible, results are clearly good, with a mean value of 2.15 points for the last year (unusually high). Similar results are obtained year after year. This is due to the fact that the adoption of PBL methodologies came along with higher demands from the students. It can be said that students who simply passed the subject in the last year have probably a better knowledge of the subject than those who obtained good marks some years ago. In the year 2006/2007, a more complex microcontroller substitutes previous simpler one, what was the probable reason for the diminution of the overall marks. New microcontroller is more powerful but also more challenging to manage. This problem was overcome with the inclusion of examples of the use of the new microcontroller in the practical lessons. Unfortunately, many students based their projects in fragments of code taken directly from the manufacturer, with terrible consequences on its quality and performance. More control of the students work during the semester was needed, and deliverables were demanded. No code from the manufacturer was provided, and the specification of the evaluation was more clearly described.

As it was shown in previous results, teaching changes have a direct consequence on the results, becoming necessary to apply some measurements to mitigate this effect. These circumstances may appear as well when adapting subjects to the EHEA, something that should not affect the students.

4 PROBLEMS IN THE IMPLANTATION

As it was previously mentioned, the impact of PBL methods must be analyzed from different points of view. Since these three subjects have quite different features, it is not appropriate to make a direct comparison among them. Therefore, to understand well the impact and the applicability of these new teaching techniques we must bear in mind current studies plans, and different parameters of each subject.

Optional subjects, normally with lower students, allow an easier adoption of PBL methods. It is clear that with hundreds of students it becomes much more difficult to pay special attention to every student. For this reason, the number of students per class should be constrained. Additionally, teachers have a certain number of hours of lectures, along with researching and managements tasks.

Main and mandatory subjects demand higher levels of knowledge, and final exams still are the most common tool among them to assess the students’ level individually. In the case of experimental and technical degrees, this effect is palliated to some extend by means of the combination of theoretical and practical lessons. Optional subjects are more flexible, opening the door to more abrupt changes.

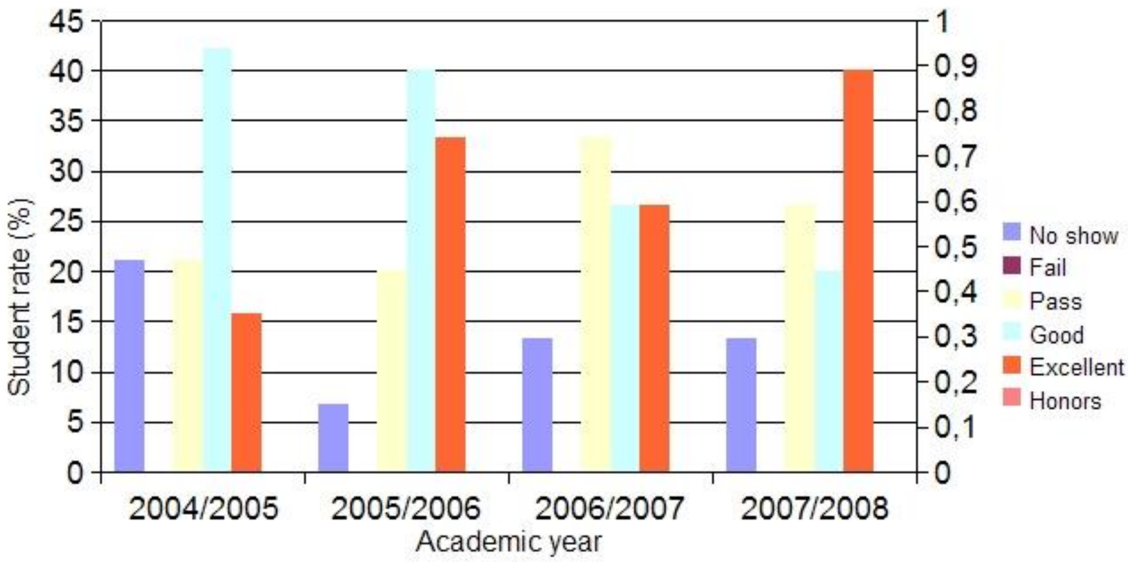

Fig.3. Results in Design based on Microprocessors.

Although motivation can be considered as a challenge, it is also true that a student that voluntary applies to an optional subject are more motivated to cope with new methodologies, even if they demand more time. This is the case of the application of PBL to Design based on Microprocessors during the last years. The level of knowledge of students is clearly higher now, and even though the work necessary to stick to deliverables and final project was bigger than previous years, when students only have to prepare a final exam. However, the number of hours is still within the designated ECTS credits.

Until the point when there are more details about how much actual work lecturers will have with the EHEA, it will be usual that lecturers stay skeptical about new teaching techniques that increase significantly teaching efforts. In our case, the attitude of all lectures was excellent, what made feasible the successful adaptation to PBL methods in two mandatory subjects and one optional.

The most common system in engineering schools and faculties is based on master classes plus practical reports, and novel teaching schemes such as the one presented require new efforts that are not always welcome. PBL requires more attention during lectures, but also a more conscientious initial preparation of specifications for guided lectures, search of extra literature that will support self-learning, and even the learning process itself of the lecturer of how to cope with projects efficiently. Including schedules and many other additional tasks for monitoring the students also come along. This is especially hard during the first years of adaptation. Contrary to the academic calendar, subjects are not stuck to one semester if we take into account not only the rest of official dates for evaluation, but also the remarkable amount of extra work connected to all the materials delivered by the students.

5 CONCLUSIONS

This paper presents the upgrade on teaching methodology in several subjects in the area of electronic technology by means of integrating active learning techniques. The experience of applying these changes to three subjects that belong to the degrees of Computer Science Engineer and Graduate in Computer Science, branch Systems, has been described in detail. Problem based learning is one of the most famous methodologies in EHEA adaptation and is considered as an active and cooperative technique of teaching. This work shows how PBL can be successfully applied in the previous subjects, with the aim of integrate an active learning process.

It was described how the adaptation was carried out during the last years. Now, the impact of PBL and cooperative learning is remarkable, and the students feel more guided in their work, and encouraged to self-learning and team work.

Results coming from our experience show very positive results in the students, although the raise of motivation and final real knowledge of one subject are difficult to estimate. However, PBL and, generally,, cooperative learning techniques and the adoption of EHEA paradigms, are not always easy. For this reason some fundamental challenging aspects were discussed in the paper. These concern not only the lecturer, but also students who must cope with new methods that result novel for them. Different features of each particular subject, such as if the subject is mandatory or optional and the number of students per class, are some of the main factors to be considered when applying PBL and EHEA-related approaches.

As it was explained, the adaptation process is continuously chancing. For the next year, deliverables of Embedded Systems will be collected during the course itself, just as in the case of Design based on Microprocessors. We expect that this will help the monitoring of the student. A new perspective will be applied regarding the act of defence of the project. Instead of a private interview, students will make a public presentation in front of their classmates. Public defence of one work is important for an engineer, and it is included as an important aspect of PBL. Finally, in the subject of Technology and Electronic Systems we will keep on working in searching of a more efficient cooperative strategy, and the design of new activities that will motivate the daily work of the students.

6 ACKNOWLEDGEMENT

This work has been carried out by members of the research group of Intelligent Systems and Telematics of the University of Murcia, inside the Spanish Program to Aid Groups of Excellence of the Séneca Fundation, under grant 04552/GERM/06. The work has been additionally supported by two EHEA pilot projects: “Avances en la Innovación Educativa y en Nuevos Enfoques en Metodologías Docentes en la Ingeniería Informática” and “Una propuesta de adaptación al EHEA en asignaturas de Tecnología Electrónica utilizando el Aprendizaje Basado en Proyectos”, sponsored by the University of Murcia.

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