Int. J. Engng Ed. Vol. 25, No. 1, pp. 152–160, 2009
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Educational Experience of Adaptation of the First-Year Course of the EUIT de Telecomunicacion to the European Higher Education Area*

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In this paper, the educational experiences of research in Engineering Education in the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion at the Universidad Politecnica de Madrid are presented. The research attempted to go beyond the experiences in the framework of the European Higher Education Area during the academic years 2005–2007. This paper describes the experience within the first-year course in the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion. Three years after the beginning of this research some feedback is given and some conclusions are drawn.

Keywords: educational experiences; engineering education; European Higher Education Area; collaborative work

INTRODUCTION

THE RESEARCH presented in this paper is a fundamental part of the project entitled 'Adaptation of the first-year course in the Escuela Universitaria de Ingenieria de Tecnica Telecomunicacion at the Universidad Politecnica de Madrid to the European Higher Education Area'. The work began three years ago (during the academic year 2005–2006) and comes within the framework of the European Higher Education Area during the academic years 2005–2008.

In accordance with [1], the main objectives of the European Higher Education Area are to contribute to the development of quality education by encouraging cooperation between Member States of the European Community through a wide range of actions, such as promoting the mobility of citizens, designing joint study programmes, establishing networks, exchanging information and teaching the languages of the European Union.

Moreover, in order to facilitate the mobility of students and teachers within the Union and the recognition of studies abroad for both academic and professional purposes, several initiatives have been launched at European level, including the European Credit, the Transfer and Accumulation System (ECTS) and the 'Diploma Supplement' (in cooperation with the Council of Europe and UNESCO) and the NARIC network (network of National Academic Recognition Information

* Accepted 5 October 2008.

Centres in the member states of the European Union, the countries of the European economic area and the associated countries in central and eastern Europe and Cyprus).

Also, in terms of quality assurance in higher education, a European Network of Agencies called ENOA was set up in 1999, following a pilot-project and a recommendation adopted in 1999 [1].

However, the two aspects of the European Higher Education Area most related to the change in the teaching and learning process are the ECTS and the quality assurance in higher education. In accordance with [2], the ECTS is based on the student workload required to achieve the objectives of a programme. This system is focused on improving the learning process, teaching methods, organisation and preparation and on interactions with students. Furthermore, all member states of the European Union should be provided with a national system that assures the quality of the content and the organisation of the studies.

In this paper, the results of the educational experience of two years of adaptation of the first-year course in the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion at the Universidad Politecnica de Madrid to the European Higher Education Area are presented. In the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion, both the ECTS and the quality assurance in higher education have played a significant role in the teaching and learning methodology during the last three academic years.

EARLY EDUCATIONAL EXPERIENCE STAGE: ACADEMIC YEAR 2005–2006

At this stage of the research, the key issue was the coordination between the professors who had voluntarily agreed to participate in the research. Thus, after each meeting of the research group several important decisions regarding the curriculum development and the application of the ECTS to the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion were made. These decisions were focused on the following issues:

1. determining the student workload and its translation to the ECTS;
2. developing new educational methods that guarantee perfect harmony between all the subjects;
3. promoting tutor sessions;
4. applying the same evaluation methods in all the subjects;
5. setting the standards for using the virtual learning environment;
6. strengthening the cooperation between all the subjects taught during the academic year.

In the early stage of the research project, 32 first-year students were chosen to participate in this educational experience. These students were chosen at random from a group of 150 new first-year students who volunteered to participate in the project.

These students have both a lecture room designed to facilitate teamwork (with Wi-Fi technology, laptop computers, a slide projector and adjustable desks aimed at making the students feel comfortable in the classroom), and a laboratory room consisting of 16 student workbenches equipped with the conventional laboratory instrumentation that can be found in an electronic engineer's workbench [3].

Information about the subjects involved in this research is shown in Table 1. In this table, one LRU (Ley de Reforma Universitaria) credit stands for ten classroom hours, without taking into consideration independent and private study or the preparation of projects and examinations.

Finally, it is important to point out that out of the 9 school departments, 6 actively participated in this research.

The academic year workload in ECTS

In accordance with the recommendations made by the European Commission [1, 2], the ECTS is based on the principle that 60 credits measure the workload of a full-time student during one academic year. The student workload during a full-time study programme in Europe usually amounts to around 1500–1800 hours per year, where cases one credit represents around 25 to 30 working hours. Credits in ECTS can only be obtained after successful completion of the work required and appropriate assessment of the learn-

Table 1. The subjects involved in the research project.

Subject	Type	LRU credits	Semester	Number of professors
Analysis of circuits—I	Fundamental	7.5	First	1
English	Mandatory	4.5	First	1
Mathematics—I	Fundamental	7.5	First	2
Programming languages—I	Fundamental	6.0	First	1
Logic Systems	Fundamental	6.0	First	1
Analysis of circuits—II	Fundamental	6.0	Second	1
Mathematics—II	Fundamental	7.5	Second	2
Electronics	Fundamental	9.0	Second	1
Physics	Fundamental	7.5	Second	2
Programming languages—II	Fundamental	6.0	Second	2

Table 2. The academic year workload in hours.

Subject	Hours/ semester	Hours/ week	Lecture sessions (hours/week)	Laboratory sessions (hours/week)	Student WLAC (hours/week)
Analysis of circuits—I	190.48	11.40	3	2	6.40
English	114.29	6.30	3	0	3.30
Mathematics—I	190.48	11.4	5	0	6.40
Programming languages—I	152.38	8.80	2	2	4.80
Logic systems	152.38	8.80	4	0	4.80
	1st semester → 800 hours/semester → 46.7 hours/week				
Analysis of circuits—II	133.33	7.55	3	1	3.55
Mathematics—II	166.67	9.80	4	1	4.80
Electronics	200.00	12.00	4	2	6.00
Physics	166.67	9.80	5	0	4.80
Programming languages—II	133.33	7.55	2	2	3.55
	2nd semester → 800 hours/semester → 46.7 hours/week				

ing outcomes achieved. The student workload in ECTS consists of the time required to complete all the planned learning activities such as attending lectures, seminars, independent and private study, preparation of projects and examinations.

In the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion, the first-year students' academic year consists of two semesters: the first has 31.5 LRU credits and the second has 36 LRU credits. Each semester consists of 15 teaching weeks, excluding the examination weeks.

Thus, in the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion it was decided to design each semester taking into consideration that the student workload is 800 hours and that the students devote 20 hours at the end of the semester to studying each individual subject in order to pass the final exams in each subject. Therefore, the total student workload per semester is 900 hours, which means that 1 ECTS credit represents 30 working hours.

The academic year workload in hours in accordance with the European Higher Education Area is shown in Table 2, where 'Student WLAC' is the student workload outside classes (i.e., after lecture and laboratory sessions).

Therefore, in order to convert LRU credits into ECTS credits, it can be seen that the 31.5 and 36 LRU credits of the first and second semester have been divided into ten subjects as follows:

1. Analysis of Circuits -I: 23.80% of 31.5 LRU credits
2. English: 14.30% of 31.5 LRU credits
3. Mathematics -I: 23.80% of 31.5 LRU credits
4. Programming Languages -I: 19.05% of 31.5 LRU credits
5. Logic Systems: 19.05% of 31.5 LRU credits
6. Analysis of Circuits -II: 16.67% of 36 LRU credits
7. Mathematics -II: 20.83% of 36 LRU credits
8. Electronics: 25.00% of 36 LRU credits
9. Physics: 20.83% of 36 LRU credits
10. Programming Languages -II: 16.67% of 36 LRU credits.

The ECTS credits for each subject are shown in Table 3.

Common teaching-learning methodology strategies used in the research

Here, the teaching methodology was based on student-centred teaching strategies, which focused on the needs and perceptions of the students, in order to develop their cognitive abilities [4].

In this sense, collaborative and cooperative learning methodologies were used. The students worked together in small groups inside and outside the classroom; they interacted in purposely structured heterogeneous groups to support the learning of themselves and others in the same group in order to build cooperation skills [5–8]. This learn-

Table 3. Subjects and their ECTS credits.

Subject	Type	ECTS credits	Semester	Number of professors
Analysis of circuits—I	Fundamental	7.14	First	1
English	Mandatory	4.29	First	1
Mathematics—I	Fundamental	7.14	First	2
Programming languages—I	Fundamental	5.71	First	1
Logic systems	Fundamental	5.71	First	1
Analysis of circuits—II	Fundamental	5.00	Second	1
Mathematics—II	Fundamental	6.25	Second	2
Electronics	Fundamental	7.50	Second	1
Physics	Fundamental	6.25	Second	2
Programming languages—II	Fundamental	5.00	Second	2

ing process was carried out under the supervision of the instructor who also acted as a coach and facilitator.

The scheduling of the subjects followed a common pattern:

1. Before each class, students were encouraged to read a few sections ahead in the textbooks used in the class and to discuss the material in order to come to class prepared.
2. The lecture and laboratory sessions in the lecture room and the laboratory room were based on student-centred teaching strategies.
3. After each class the students were given homework activities to be done in small groups or in independent and private study.

An example of one of the strategies used during the research, is in the subject Analysis of Circuits I; in the classroom we held five debates on key issues of the topic (5 units of work, 1 debate per unit of work), the students participated in internet forums using the Moodle platform where they asked questions about specific issues and other students (and sometimes the instructor) answered the questions. The internet forums also allowed the instructors to identify the specific problems or weaknesses of the students in the subject throughout the semester and to address them in the lectures.

Also, in each class the instructors themselves solved several short problems as examples so that the students could better understand the contents; approximately 50% of the time was devoted to solving long problems with small groups of three to five students in cooperative and collaborative activities. During this classroom process each instructor supervised the work of the students and acted as a coach and facilitator.

As part of the continuous assessment tasks throughout the semester, the students were given many exercises to solve in small groups both in the class and as independent study. At the end of each of the 5 units of work on the subject each student had to take two 10-questions knowledge tests and as well as two exam papers.

In addition, all the laboratory sessions were based on collaborative learning activities. The students worked in small groups of two people for 30 hours. They had to build more than 30 electronic circuits and carried out all the requested measurements using the laboratory instrumentation on their workbenches.

At the end of each laboratory session each group of student had to hand in the results of their experiments for the instructor to assess them, and the last laboratory session of the semester was devoted to an exam in which each individual student had to build a specific electronic circuit and carry out some specific measurements.

Promoting tutor session

At the beginning of each semester, small groups of students, consisting generally of no more than four students, were formed and encouraged to sign up for a 30-minute long tutor session in which the professors showed them the importance of the tutor sessions to both the individual student and to each small group of students, taking into consideration their strengths and weaknesses [9].

Assessment methods

The evaluation system that all the professors used in this educational experience was a blend between the traditional student assessment of learning system and that based on continuous assessment, which is designed to make it possible for the students to keep up their own progress in their studies and make improvements where needed. Also, it is aimed at facilitating the process of identifying the strengths and weaknesses of the teaching and learning environment as well as raising the quality of teaching of each subject.

In general, in the first two academic years of the research project the marking scheme for each subject was constructed as follows: 70% final exam paper and 30% continuous assessment.

In short, the reason why we chose the above percentages is that the professors who participated in the experiment wanted to assess the performance of the students who studied under the European Credit Transfer and Accumulation System in the final exam papers of each subject, and compare their performances against those of the students who studied under the traditional system. We decided the above percentages for the first two years by consensus.

However, taking into consideration the results of the first year of the educational experiment and the outstanding performance of the students who studied under the European Credit Transfer and Accumulation System in the final exam papers, in the second year of the experiment there were subjects such as Analysis of Circuits—I and II in which students who had an outstanding performance throughout the semester in the continuous assessment tasks (the ten 10-questions knowledge tests, the two exam papers, the laboratory exam and so on) did not have to do the final exam papers.

Virtual learning environment (VLE)

The software system used in the research project was Moodle, which is a well-known free-software e-learning platform, and all the professors who participated in the research used b-learning (i.e., blended learning) to improve their teaching efficiency.

The VLE was used to provide follow-up materials online, continuous assessment tasks for their (online) discussion, homework assignments, and online activities or exercises. Also, it was used to make available the material from the professors and the scheduling of each unit of work, to participate in forums assigned by the professors, and to provide forum questions and e-mentoring or e-tutoring [10–12].

Collaborative work

The group consisting of the professors who participate in the research and the student representatives work together to create a mutual knowledge structure derived from group consensus. They work together in order to identify and define the problems of the teaching and learning methodology, to search for solutions on which the group can agree, to test out hypothesis about the solutions, and so on. Since the start of the research project, on average, the above-mentioned group has had bi-monthly meetings.

SECOND EDUCATIONAL EXPERIENCE STAGE: ACADEMIC YEAR 2006–2007

At the end of the second semester of the academic year 2005–2006, the academic results of the group of Students who participated in the Educational Research Project (SERP) were compared with those of the students who did not participate in the project (i.e., the students who followed the Traditional Teaching and Learning Methodology (SFTM)).

The above-mentioned comparison was made taking into consideration the *performance rate*, the *success rate* and the *drop-out rate* of the students at each particular semester.

The *performance rate* is defined as the ratio of number of credits that the students obtained, without taking into consideration the credits awarded on the basis of condonement or compensation, to the number of credits for which the students are enrolled.

The *success rate* is defined as the ratio of the number of credits that the students have obtained, without taking into consideration credits awarded on the basis of condonement or compensation, to the number of credits that the subjects have.

The *drop-out rate* is defined as the ratio of number of credits for which the students who have dropped-out are enrolled to number of credits for which both the students who have dropped-out and those that haven't dropped-out are enrolled.

As a result of such a comparison, it could be seen that, in general, in both semesters the drop-out rate of the SFTM was very much higher than that of the SERP. Also, the percentage of SERP who passed the subjects was higher than that of the SFTM who passed the subjects, and the success rate of the SERP was higher than that of the SFTM.

Figure 1 shows the performance rate, success rate and drop-out rate at the end of the first semester of the academic year 2005–2006. Figure 2 shows the same information at the end of the second semester.

Here, it should be pointed out that the subjects that showed a significant improvement in the performance of the students were Analysis of circuits—I, English, Mathematics—I and Physics. Despite the fact that the other subjects had satisfactory results, their results were not significantly better than those obtained using the traditional methodology.

In general, both the students and the professors who participated in the research project were quite happy with the academic results of the academic year 2005–2006, and it was decided to increase both the number of students and the number of professors involved in the project for the second year of this educational experience in engineering education.

Therefore, in the academic year 2006–2007, 90 new first-year students participated in the project as well as 17 professors. In the second year of the educational project the students were not asked to volunteer for the project. However, all of them had been informed about the project when they enrolled at the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion in the academic year 2006–2007, and they had been told that some of them were going to be chosen at random to participate in such a project.

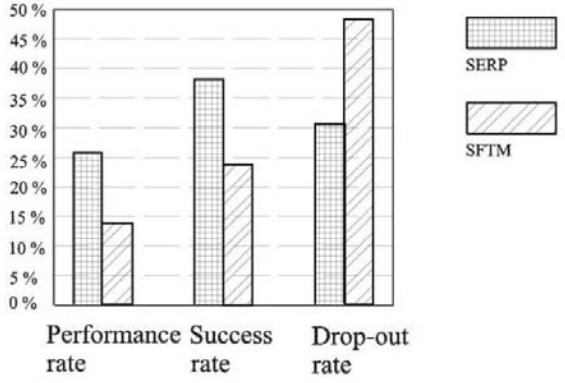

Fig. 1. February 2006: performance rate, success rate and drop-out rate at the end of the first semester of the academic year 2005–2006.

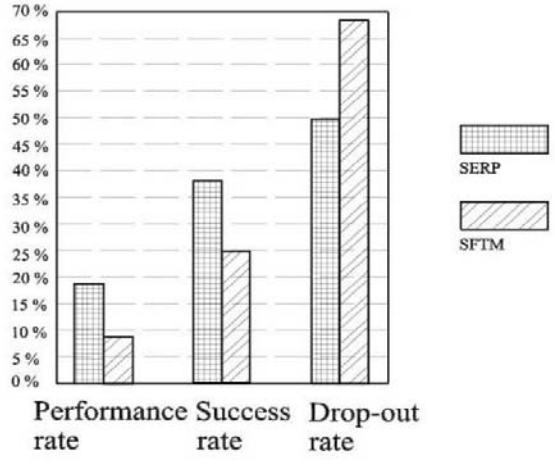

Fig. 2. June 2006: performance rate, success rate and drop-out rate at the end of the second semester of the academic year 2005–2006.

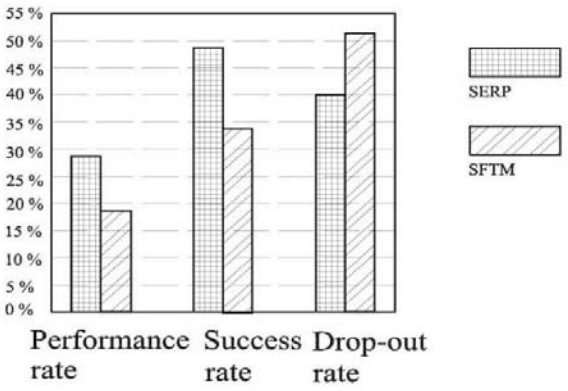

Fig. 3. February 2007: performance rate, success rate and drop-out rate at the end of the first semester of the academic year 2006–2007.

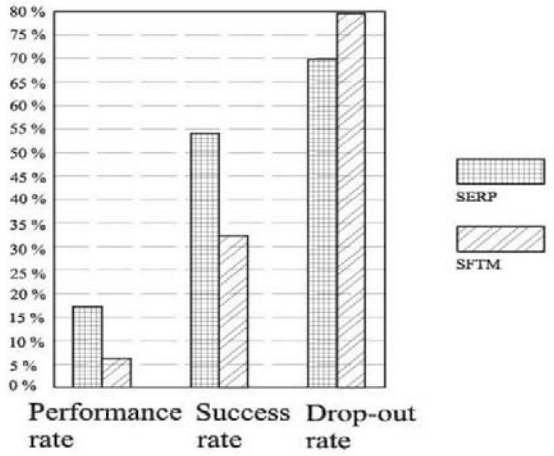

Fig. 4. June 2007: performance rate, success rate and drop-out rate at the end of the second semester of the academic year 2006–2007.

Figure 3 shows the performance rate, success rate and drop-out rate at the end of the first semester of the academic year 2006–2007, and Fig. 4 shows the rates at the end of the second semester.

In the academic year 2006–2007, the subjects that showed a significant improvement in the performance of the students were Analysis of circuits—I, Mathematics—II and Programming languages—II. Although the other subjects had satisfactory results, their results were not significantly better than those obtained using the traditional methodology.

CURRENT EDUCATIONAL EXPERIENCE STAGE: ACADEMIC YEAR 2007–2008

As the general opinion of the SERP, the SFTM and the professors about the outcomes of the first two years of the research project on engineering education was quite positive, it was decided to apply the new methodology to all the new first-year students of the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion in the present academic year.

The two things that both professors and students valued most were the continuous assessment and the use of the VLE as a support both to develop student learning skills and to promote collaboration and cooperation between students.

On the other hand, as well as teaching, university professors also have to research in other fields such as Telecommunication Engineering, Electronics, Physics, Mathematics and so on. The general opinion of the professors was that the change from the traditional teaching and learning methodology to the new one had caused an increased in their workload, at least in the first two stages of the educational research project. Also, in spite of the fact that most of the students who participated in the project were in favour of the new methodology, some of them thought that the workload is higher [13, 14].

Therefore, in order to make the system more efficient during the academic year 2007–2008 and to find one that works best for both professors and students, some decisions were made.

Decisions that have already been implemented this academic year and that have yielded satisfactory results are as follows.

1. This academic year there are two kind of groups of students: one consisting of new students and the other consisting of students who are retaking the subjects.
2. The marking scheme for each subject is no longer 70% exam paper and 30% continuous assessment, as in the previous two years. Currently, in many subjects, it depends more on continuous assessment tasks (i.e., partial exams, tests, projects, homework assignments, and so on) than on the final exam paper. In fact, in some subjects, outstanding students do not have to sit the final exam paper; they pass the subject if their performance in the continuous assessment tasks is very good.
3. This academic year there are faculty and student mentors who are interested in ensuring that the new students (first-time freshmen) and students who experience socio-economic, academic, and personal challenges can have a successful academic year.
4. Finally, for this academic year all of the first-year student lecture rooms of the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion have been designed to facilitate teamwork between students and to make them feel comfortable in class.

Currently, the first semester has not yet finished. The students are in the examination weeks. But, we

think that the academic results of this academic year will be better than those of the previous two academic years.

VIEWS OF THE STUDENTS AND PROFESSORS

During the three academic years of the research project, the level of satisfaction of the students has been high and their reactions to the new methodology have been positive. However, there are still many things that should be improved.

In general, the following conclusions can be drawn from the surveys carried out amongst students that have participated in the research project.

1. The students pay more attention to the classes that use the new methodology because they have realized both that they learn more and that they pass the subjects with better final grades.
2. The continuous assessment has enabled the students to understand the areas in which they are having difficulty and to concentrate their efforts in those areas.
3. The partial exams, tests, (online) discussion and teamwork projects, among other activities, are highly valued.
4. The students do not like the professors to control their attendance at classes. They prefer to attend classes in which they feel more comfortable and in which the professors use interactive methods to break the monotony, are approachable, present information in an effective way, recap information taught during the class and in previous lessons, and so on.
5. The fact that, in some subjects, if the students give an outstanding performance during all the semester they do not have to sit the final exam paper, is highly valued.
6. Most of the students strongly disagree with the fact that in most subjects they have to sit the final written exam regardless of their good performance during the semester. The continuous assessment process is much more efficient than a final written exam.
7. The use of the VLE is highly valued, and the VLE has been of paramount importance for students who are working and studying at the same time.
8. The student mentor is highly valued.
9. The general student workload is still high. As a result, some of the students have to drop out from some subjects in the middle of the semester.
10. In general, the connection between subjects should be improved.

The views of the professors who have participated in the whole research project or in any of its stages can be summarized as follows.

Weaknesses

a. As the student workload is high, many of them drop-out from some subjects.
b. As the professor's workload is high, some professors do not want to change the traditional methods of teaching.

Dangers

a. There is still a lack of communication between the professors who are participating in the project and the ones who are not participating in it.
b. Some professors do not see the importance of the new methodology, they prefer the traditional methods.
c. Some professors do not consider research in Engineering Education to be scientific research.
d. In order to improve communication, teamwork and lateral thinking, the amount of interdisciplinary lessons should be increased.

Strengths

a. Student teamwork.
b. Continuous assessment.
c. The overall improvement of the student performance in all the subjects.
d. The new marking scheme for each particular subject.
e. The blended approach to teaching, face-to-face and e-learning.
f. The use of interactive methods to break the monotony.
g. The use of the VLE.
h. Good coordination and cooperation between all the professors who are participating in the project.
i. Students feel more comfortable in classes.
j. Professors are more approachable, available, and willing to meet.
k. The faculty and student mentors.

Opportunities

a. The project started at a time in which all the universities in Spain are adapting the curriculum content of their technical degrees to the European Higher Education Area, and in spite of the fact that there is still room for improvement, the research in Engineering Education presented here has yielded satisfactory results for three consecutive years, which has allowed us to enjoy the benefits of the new teaching and learning methodology, and to be prepared for collaboration and cooperation in excellence in engineering education with other member states of the European Community.
b. As this project and some members of the engineering education research team have received recognitions and awards from the Rector of the Universidad Politecnica de Madrid during the academic years 2005–2006 and 2006–2007, we have received institutional support and won the opportunity to have this

research totally supported by the Universidad Politecnica de Madrid under several research projects on 'Innovative Education and the European Higher Education Area'.

CONCLUSIONS

In this paper, the results of a research on Engineering Education in the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion have been presented. During these last two academic years, much has been learned from involving both professors and students in the complex process of teaching and learning, and from adapting Engineering Education at university to the European Higher Education Area.

The academic results, the views of the students, and the views of the professors have shown that, despite there being room for improvement, the continuous assessment, teamwork projects, collaborative and cooperative learning, the use of a satisfactory VLE, the blended approach to teaching, faculty and student mentors, and so on, are the right way to go.

From the results of this research, professors at the Escuela Universitaria de Ingenieria Tecnica de Telecomunicacion have learned that the traditional teaching and learning methodology is soon to be obsolete, and that we have to adapt to meet the needs of modern society. There is a gap between professors and students in the traditional teaching and learning methodology that should be bridged.

Acknowledgment—This work has been supported by the Universidad Politecnica de Madrid under the educational research project IE075902067.

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