Abstract - The present paper discusses results of the global study carried out during the past two years to estimate the student workload (an ECTS preliminary estimate) for the first course of the degree in Electrical and Electronic Engineering. At the same time, the different methodologies advocated by the European Space for Higher Education have been put into practice in order to promote the acquisition of both specific and generic competences and skills belonging to the degree. The process of adaptation to the new European Space for Higher Education brings with itself a new understanding of both teaching and learning procedures. The gradual adaptation of the subjects will allow lecturers to act carefully and thoughtfully when facing the necessary adaptation to the new educational framework; results obtained will let us correct the tested methodological strategies and work on their improvement.

Index Terms – Competences, ECTS, European Space for Higher Education, Teaching Methodologies.

INTRODUCTION

The general directives to adapt educational systems to the European Space for Higher Education (ESHE) are related to the competitiveness of the European Higher Education Area (EHEA), to students and lecturers' mobility as well as to the incorporation of students in the industrial and business world [1]. Everything will cause deep changes. We believe that the main change will take place in the teaching methodology. So far, what students acquired in a few years was supposed to be enough for the rest of their professional lives. The vertiginous technological advance of our society entails continuous learning and this is generating a necessity of using educational models that allow the students to "learn to learn". From the student's point of view these educational models are more active.

The Teruel Polytechnic School of Engineering [2] has been developing actions of innovation and educational improvement for several years. Actions carried out by the different management boards and by teaching committees of our university have tried to involve both lectures and students.

The present paper shows the global study fulfilled during the past two years. It began in academic year 2006/2007 with the design of the first course of the Electrical and Electronic Engineering degree from the ECTS standpoint. In academic year 2007/08 the study was put in practice. The same operating way is being developed at the moment for the second and third year of the degree.

The curriculum of this engineering degree, focused on electronic systems, is designed to promote the students' ability to detect and analyze technological problems using decision-making tools and problem-solving processes. The main sections of this study were:

- Degree analysis: professional profile and general and specific competences.
- Elaboration of the new teaching guides.
- Initial assessment: developed strategies and possibilities of generalization and implementation of the study carried out.
- Description of teaching methodologies to be used.

Several sources have propounded the advantages offered by considering different methodologies in order to acquire the skills and competences students will need in their future jobs. Interpersonal communication, teamwork, group problem-solving, leadership, negotiation and time management [3-6] are examples of these competences. In addition, positive effects have been shown in students' academic performance, in motivation and their attitudes towards learning [7]. Some of these advantages have also been underlined by students, who consider group activities and active methodologies to be more interesting and entertaining than traditional teaching [8].

This paper is presented as follows. Section 2 presents the previous and preliminary theoretical analysis of both first year curriculum and competences to be acquired by students at this level. Sections 3 and section 4 deal with the used teaching methodologies and planned activities, respectively. Section 5 puts in practice the theoretical study, showing a comparative analysis between both theoretical and practical student workload. Finally, section 6 presents the main conclusions.

PRELIMINARY ANALYSIS OF CURRICULUM AND COMPETENCES. ACADEMIC YEAR 2006/07

I. Introduction

Along the course year 2006/07, lecturers in charge of the subjects of the first course of the degree set up a workgroup to analyze the curriculum as well as the competences and
skills to be acquired by students. They worked on both individual and group basis. The group of lecturers had the support of the Education Sciences Institute, belonging to the University of Zaragoza, aimed at facilitating the training on curricular design under the perspective of the ECTS (European Credits Transfer System).

One of the first goals of the project was the design of a new educational guide according to ESHE. To prepare the guide the following tasks were developed:

- Task 1: Description and contextualization.
- Task 2: Analysis of competences.
- Task 3: Definition of the objectives of each subject.
- Task 4: Selection and organization of the contents.
- Task 5: Teaching methodology and work plan.
- Task 6: Assessment.

II. Description and context

The curriculum of the first year degree under consideration consists of the subjects shown on table I.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis of circuits and linear systems (1st &amp; 2nd TERM)</td>
<td>8.8</td>
</tr>
<tr>
<td>Calculus (1st TERM)</td>
<td>4.8</td>
</tr>
<tr>
<td>Programming I (1st &amp; 2nd TERM)</td>
<td>7.2</td>
</tr>
<tr>
<td>Electric and Magnetic Materials (1st TERM)</td>
<td>6</td>
</tr>
<tr>
<td>Algebra (1st TERM)</td>
<td>4.8</td>
</tr>
<tr>
<td>Physics I (1st TERM)</td>
<td>3.6</td>
</tr>
<tr>
<td>Physics II (2nd TERM)</td>
<td>4.8</td>
</tr>
<tr>
<td>Mathematics (2nd TERM)</td>
<td>7.2</td>
</tr>
<tr>
<td>Graphical Design: (2nd TERM)</td>
<td>4.8</td>
</tr>
<tr>
<td>Statistics (2nd TERM)</td>
<td>4.8</td>
</tr>
</tbody>
</table>

In the framework of ESHE the credits meaning changes [9]. ECTS credits measure all the academic work carried out by one student to reach the objectives. Therefore, these credits include activities such as class attendance, both theoretical and practical, lessons preparation, individual study, tests and exams, guided projects, seminars and tutorials. One ECTS credit should be between 25 and 30 hours of student’s work [9]; moreover, experience will show us that the value of a credit in engineering degrees usually is closer to the second value.

III. Analysis of competences

The Spanish Organic Law of Universities [10], in its first article establishes "The creation, development, transmission and criticism of Science, Technology and Culture" as the first function of a University. Consequently, students must develop intellectual, technical, artistic, social and personal abilities. These abilities or competences will encourage creativity, problem solving and autonomous learning through all their life.

IV. Objectives, contents, methodology and assessment

Once the competences were outlined, each lecturer determined the subject objectives and related them to both generic and specific competences. Afterwards, they detailed contents and teaching activities. The activities outlined were selected from Alfaro [13] where they were classified into big group work, seminars, practical classes, ECTS tutorials, autonomous work in groups and individual autonomous work. We expected that the educational model would not be centered exclusively on lectures but rather it would promote different types of work such as group work, individual study and tutorials.

As a result of the activities designed, lecturers estimated the number of hours that every single student would have to work to pass each subject. Finally, once the planning and the sequence of activities were designed, lecturers established the subject assessment criteria. All the obtained data were collected and a new first course guide was generated.

TEACHING METHODOLOGIES

In the framework of ESHE, it is desirable to use some new teaching methodologies in order to promote student motivation and attention. This choice will depend on the different situations: group size, objectives, class context, available time, student characteristics, lecturer point of view, etc. To choose one of them it is necessary to know their

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The Tuning project [11] proposes a total of 30 competences classified in three groups: instrumental, interpersonal and systemic. To carry out the present teaching guide we considered the generic competences that were specified in the Electrical and Electronic Engineering guide proposed by ANECA [12], where the importance of each of them was valued starting from the results analysis of surveys carried out to company communities, qualified people and lecturers.

We selected from that guide the main competences that our students had to develop and we used them as the starting point to design our subjects. Moreover, we decided to assign a weight to each of these competences. Therefore, lecturers assigned a value to each competence depending on the importance they thought the competence had on their subjects. The most valued competences were: analysis and synthesis ability, organization and planning ability, resolution of problems, ability of working in teams and critical reasoning.

We assume that the competences selected were supposed to develop in the first year of the degree; the rest of the competences would be developed in higher courses when students are better trained.

Once the generic competences were defined, we studied the specific competences. Some of the selected specific competences were: hardware technology, ability to understand and valuate internal and external specifications, applications design concepts and up to seventy-three more specific competences.

In the framework of ESHE, it is desirable to use some new teaching methodologies in order to promote student motivation and attention. This choice will depend on the different situations: group size, objectives, class context, available time, student characteristics, lecturer point of view, etc. To choose one of them it is necessary to know their
benefits and drawbacks having a clear and well-defined goal at the same time.

In this context, lecturers play an important role, but it is not anymore exclusive in the knowledge transmission. So far, the lecturer used to plan the activities progress done in the classrooms. From now on, he should also specify those activities that students fulfill out of classrooms, taking into account this relevant workload and reflecting them via ECTS.

Concerning the distribution of this kind of activities, we have opted for the following classification [13]:

- **Big group:** Traditional lectures with explanatory and/or demonstrative sessions about contents, where presentations taken place on the side of both lecturers and students.
- **Seminars/workshops:** aimed at building knowledge through the interaction and activity among lecturer and students. Monograph supervised sessions with shared participation among lecturer and students are fulfilled.
- **Practical Sessions:** (aimed at showing how students should operate). No matter the kind of classroom practice, for instance, problem-based-learning, laboratory exercises, computer science laboratory classes, data searching, library activities, internet, company visits, etc.
- **ECTS Tutorials:** (student personalized attention). The lecturer deals with students in order to advise them in the different activities belonging to the subject.
- **Non-assisted work in groups:** (to let them learn by themselves). Seminars preparation, readings, works, essays, data retrieval and analysis, to be presented or handed in to the lecturer in the classroom.
- **Non-assisted individual work:** (to develop their self-learning ability). The same activities aforementioned should be carried out, but in an individual way. It also includes personal study for examinations, complementary readings, problems and exercises and so on.

As previously mentioned, the introduction of these new teaching and learning activities should be done step by step, in a gradual way. Furthermore, teaching activities were supported by the use of the e-learning technologies, letting students download lesson notes, practical works, as well as take part in activities such as chats, groups, forums, etc. The drawing-up of concept maps served us as back-up in some occasions along the formative process. Nevertheless, it is necessary to bear in mind, some aspects:

- Practical work does not begin until basic theory has already been taught. Thereby students will be able to apply it to a particular laboratory case.
- Students normally devote a small number of hours at the very beginning of the term. So, this lack of work should be made up towards the end of term.
- Theoretical concepts taught at the end of each term are difficult to be reinforced, because of the lack of time to develop practical activities related to them.
- At the end of term, we run the risk of having an overlapping in projects and works to be handed in, which can lead to abandonment in some subjects to put efforts in others.

For the above mentioned reasons, the distribution of activities was planned in such a way that students should devote forty hours per week, approximately. Taking into account both work at classroom and autonomous work, in the first term, students were supposed to devote on average 22.25 hours and 22.62 per week, respectively. As far as the second term is concerned, the planned figures were 23.35 hours per week of work at classroom and 25.7 hours per week of autonomous work. It can be pointed out that the total quantity of planned hours was slightly higher than 40 hours a week. However, the course usually begins with a greater load of activities at classroom especially lectures and problem sessions, because students do not have the necessary knowledge to develop more interactive activities. For that, it is highly recommended to give them a theoretical basis that let them develop the skills and required attitudes.

As fast as the student acquires the basic knowledge, interactive activities will be introduced step by step (seminars, practical lessons, etc.). These activities will let students have a higher level of autonomy. At this stage, new theoretical concepts will be introduced in order to deal with problems and issues more and more complex.

From the beginning of the term, students have the detailed planning, being conscious about the follow-up necessity. Table II shows the number of estimated hours that one student should devote to pass every single subject. Simply by dividing these hours into the number of ECTS credits assigned to every subject, we will obtain the number of hours per ECTS.

### Table II: Student’s Workload for the Different Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Mathematics</th>
<th>El. Magnetic Materials</th>
<th>Calculus</th>
<th>Algebra</th>
<th>Programming</th>
<th>Circuit Analysis</th>
<th>Statistic</th>
<th>Physics I</th>
<th>Physics II</th>
<th>Graphic Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (h)</td>
<td>201</td>
<td>180</td>
<td>131</td>
<td>145</td>
<td>184</td>
<td>264</td>
<td>144</td>
<td>100</td>
<td>144</td>
<td>144</td>
</tr>
<tr>
<td>ECTS (h)</td>
<td>7.2</td>
<td>6</td>
<td>4.8</td>
<td>4.8</td>
<td>7.2</td>
<td>8.8</td>
<td>4.8</td>
<td>3.6</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Ratio (h)</td>
<td>27.9</td>
<td>30</td>
<td>27.3</td>
<td>30.2</td>
<td>25.5</td>
<td>30</td>
<td>27.8</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

We estimated a total 1637.5 hours of student’s dedication. That is, a student was supposed to work an average of 28.83 hours for each credit. The total number of hours will be therefore slightly above 1600 hours; nevertheless we can see that it is within the range considered for an ECTS credit, which is between 25 and 30 hours.

By the end of the year, students had to perform a project with a medium-high complexity, taking into account all the acquired concepts and using them in a joint way. At the same time they had to do an oral presentation. We sought to promote the development of knowledge, competences and skills, as well as all the attitudes set out with the learning objectives (initiative and creativity spirit, responsibility...
sense, ability for hypothesis formulation and evaluation, planning ability, information searching and solution analysis, report drafting and so on. At this part of the term, there are fewer lectures, so the student was encouraged to do more autonomous work. The lecturer should act by channeling students in search for the problem solution. To perform that, seminars and tutorials were promoted, where a more personal follow-up (individual and groups) could be done.

**PRACTICAL EXPERIENCE. ACADEMIC YEAR 2007/08**

**I. Introduction**

During the academic year 2007/08 we started the implementation of the study developed the year before. Along that year, a great number of data was collected from both students and lecturers, to compare both theoretical analysis and practical implementation. Most of the students followed a continuous assessment, so they were supposed to work during 40 weeks divided into two terms, just as the system ECTS establishes, including exams and holiday periods. Following sections show some of the data obtained after analyzing both first and second term results. Data has been carefully analyzed and compared with the initial planning.

**II. Activities**

The main activities developed were: theoretical lessons, problem solving and group work lessons, practical laboratory work, individual tutorials, ECTS tutorials, student’s presentations and exams. Autonomous work was introduced by lecturers little by little, as first year students are not trained at all. The work in small groups (seminars and practical lessons) was promoted, in order to let students develop the acquisition of competences, both specific and generic ones.

**III. Classroom Attendance**

There is a clear difference existing among the students that follow the continuous assessment and those that do not do it. In general, the former are conscious of the necessity of subject follow-up on a daily basis, while the latter prefer to put greater effort only in the weeks previous to the exam. We saw that 52.66 % of enrolled students usually attend classes.

**IV. Student’s participation and motivation**

Depending on the subjects, lecturers valued the student's participation assigning values between 3 and 9 points; with an average of 6.33. In general, students followed lessons well, however they sometimes found it difficult to participate in some activities; some of them were not very motivated by continuous work, they did not use to study on a daily basis and therefore they found it difficult to reason and work out problems because they lacked important concepts that should already have been assimilated.

Some of the reasons that caused a low participation of the students were: lack of knowledge of intellectual work techniques, low previous knowledge, weak motivation, low self-esteem and not very clear objectives.

Something similar happens to motivation. It varied depending on the subjects. Lecturers valued with figures between 4 and 8; the final average was 6.5. Also, those students that attended lessons but did not follow the continuous assessment were less motivated and they participated less in the proposed activities.

**V. Student’s work dedication**

An academic term consists of 20 weeks distributed in 15 teaching weeks, 3 exams weeks (18th, 19th and 20th) and 2 holiday ones (weeks 14th and 15th on the 1st term and 9th and 10th on the 2nd term). Figure 1 and figure 2 show the distribution of student's workload along both terms (panned vs. real). A web-based software was designed specifically to collect the data from both student and lecturer sides. We can observe that in general, students have worked below planned.

![FIGURE 1](image1)
**FIRST TERM STUDENT’S WORKLOAD PER WEEK (HOURS). PLANNED VS. REAL.**

![FIGURE 2](image2)
**SECOND TERM STUDENT’S WORKLOAD PER WEEK (HOURS). PLANNED VS. REAL.**

Figure 3 and 4 show that student's personal work along the weeks was less than that it should have been to. Work is only superior in previous weeks before exams and in the exam period. An average student did not work in a uniform
way along the term; one student devoted 2.09 hours on average to individual work for each subject. However, the working hours changed depending on the weeks. We have observed that some students worked on some subjects 0 hours some weeks and 7.5 hours some other weeks. Nevertheless, although we can affirm that in general students have improved their habits of continuous work, they still should improve their capacity to distribute the effort in a more uniform way throughout the weeks and not to centralize it at final weeks of the terms (just before examinations).

As far as classroom attendance is concerned, it was higher than the one planned, largely due to two factors: Firstly, the students do not understand the necessity of working at home and secondly they have a lack of continuous work habit.

Fig. 5 and fig. 6 show similar conclusions as the previous tables. On one hand, student’s private work was below the planned work in almost all subjects. On the other hand, the work at classroom was higher than the planned one. Percentages are exchanged when we compare the established figures in the planning and the real ones:

- Planning: 57.96% of student’s personal work, 42.04% of work in the classroom.
- Real: 43% of student’s personal work, 58% of work in the classroom.

Furthermore, the dedication ratio changed. If we estimated 28.83 hours for ECTS credit in the planning, it became 22.18 hours for credit ECTS in practice, being this last value below the 25-30 working hours estimated for one credit ECTS.

Students devoted a total of 31.3 weekly hours on average to study and preparation of all subjects (including personal work and work at classroom). This value is lower than the planned one; the suitable number should be approximately 40 hours. Therefore, we can conclude that students should make a greater effort.

VI. Assessment

Lecturers carried out a continuous assessment in all the subjects. The weight they gave to it varied from 15% to 100% (depending on the subject), having an average weight of 43.34%. A final exam was also done in all subjects, with a weight, in this case varying from 15% to 80%, (38 % on average).

Students valued positively the use of continuous assessment; they stated that this way of assessment helped...
them to study on a regular basis. Moreover, it improved the follow-up of the subjects, facilitating the learning process and improving both the student’s interest in lessons and their performance. Those students that did not follow the continuous assessment had to do end-of-term exams; in this case this exam was the main assessment criteria. Some of the reasons for which students gave up continuous assessment were: the overlapping of different courses timetables (2nd year), the necessity of a greater effort and continuous work and lack of aptitudes for planning and organization. The number of subjects which passed at the end of the year was 7.2 subjects on average (out of 10), clearly higher than the previous year (4.6). Furthermore, most of the students following continuous assessments were successful.

VII. Student’s valuation of used methodologies

Students valued the methodologies used by lecturers in a positive way. The assigned marks oscillated between 5 and 9, averaged 6.5. On one hand, the best assessed aspects by students were: very good communication to one another in group activities, positive experience of this type of activities and a better learning regarding other methodologies. The most developed aspects according to the students were the work in groups, effective communication with the other students and autonomous learning. On the other hand, some students considered that the course had been quite difficult and the subjects had too many contents.

VIII. Lecturer’s workload

Lecturers’ dedication was higher than previous years, mainly due to the increase of work to prepare new materials, new activities, and the correction of more exams and so on. According to lecturers’ assessment, the increase of work regarding previous years was about 36% higher on average. Coordination tasks have generated a 7% of additional work. Nevertheless, they all concluded that student performance was better and acquisition of competences was clearly reinforced.

CONCLUSIONS

In this work, we have dealt with the adaptation of a complete year of the Electrical and Electronic Engineering according to the new requirements of the European Higher Education Space. The gradual adaptation of the subjects allowed lecturers to act carefully and thoughtfully when facing the necessary adaptation to the new educational framework; results obtained will let us correct the tested methodological strategies and work on their improvement. Both students and lecturers made a positive assessment of the used methodologies in terms of student learning. Although the obtained results are promising, a lot of work will have to be done to achieve the complete process of adaptation.

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AUTHOR INFORMATION

Raquel Lacuesta, department of Computer Science and Systems Engineering, University of Zaragoza, Spain, lacuesta@unizar.es.

Guillermo Palacios, department of Electronic Engineering and Communications, University of Zaragoza, Spain, guillermo.palacios@unizar.es.