Electronic Engineering PBL at the Design Engineering School of Valencia, Spain

Ballester Sarrias, E.
School of Design Engineering ETSID / Dean
Universitat Politècnica de València
Valencia, Spain

Ibáñez Civera, J.; **Masot Peris**, R.; **Alcañiz Fillol,** M.
School of Design Engineering ETSID
Universitat Politécnica de Valencia
Valencia, Spain

Garrigues Baixauli, J.; **Lidón Roger,** J.V.
School of Telecommunication Engineering ETSIT
Universitat Politécnica de Valencia
Valencia, Spain

Sánchez Ruiz, L.M.[1]
School of Design Engineering ETSID / Vice Dean
Universitat Politécnica de Valencia
Valencia, Spain

Conference Topic: Active Learning

INTRODUCTION

Project based learning methodology (PBL) [1][2] is one of the most effective methods of teaching where students not only develop the scientific and technical abilities inherent to the corresponding subjects but it also fosters knowledge about organization and management at the same time that it promotes a number of social abilities as valued nowadays as teamwork, leadership, communication, planning, etc.

This methodology is widely used and has been tested in many disciplines [3][4] and it is well-known the UK Approaches to Engineering Project-Based Learning White Paper sponsored by the Bernard M. Gordon-MIT Engineering Leadership Program, MIT [5].

In this paper we describe PBL experiences carried out in two subjects in two different degrees of the School of Design Engineering ETSID at Valencia (Spain), namely in the subject of “Digital Electronics” at the BEng in Electronics and Control Engineering and in “Electronics Technology” at the BEng in Aerospace Engineering degree.

Students do practical work in a consistent design of an electronic system in groups of 2 or 3 students. Teachers propose a project list with an adequate difficulty to the student’s knowledge level and a reasonable execution time after that, in a first step, the objectives and specifications of the prototype are clearly defined.

In all cases, the projects done by the students, end with the construction of prototypes which are openly exposed to the public in a special session.

[1] Corresponding Author Sánchez Ruiz, L.M.

1 THE STUDENTS

Students enter the university through the corresponding access marks. In the case of Engineering in Industrial Electronics and Automatic, the minimum score was 8.65/14, while in Aerospace Engineering, it was necessary to have obtained a minimum rating of 12.146/14.

As for the ages, the average is about 20 years old for both courses. For them, it is the third year at the university and they have already achieved a level of knowledge and maturity, sufficient to address the proposed methodology.

By gender, the distribution is highly skewed, and, in the case of Electronics, only 8 of the 55 students in the class were girls, while in Aerospace, of the 25 students, only 2 were girls.

2 THE SUBJECTS

In this paper two subjects from two different degrees are treated. In addition, their prior level of knowledge is also different, therefore we do have to treat them in a different manner from each other.

2.1 Digital Electronics. Title: Electronics and Automatic Engineering

The Digital Electronics is a core subject that is taught in the first semester of the 3rd year (7.5 ECTS). Previously, students have already had contact with the digital electronics in the subject Electronic Technology of the second year (9 ECTS) where content related to the binary variables, numbers, Boolean algebra and combinational logic, are discussed. Moreover, they have got some knowledge of Analog Electronics (second half of the 2nd year, 7.5 ECTS), which is intended to enable students to design and analyse, both theoretical and experimentally, any analog processing system. To do this, the following contents are studied: Introduction to analog signal processing, the study of analog signals, features an analogue processing, functional blocks and impedance matching, transistor amplifiers, operational amplifier (OA) and linear applications, OA nonlinear functions and linear power supplies.

Thus, students have learnt some fundamentals of electronics, both analog and digital, to start the subject of Digital Electronics. However, it is necessary to impart some lesson plans concerning sequential systems and microprocessors previously to the completion of classroom projects. Hence the course starts covering: digital systems, study and design of logic functions, discrete combinational and sequential systems, programmable logic, microprocessors and microcontrollers. In ulterior classes projects are carried out.

2.2 Electronic Technology. Title: Aerospace Engineering

The Aerospace Engineering graders have got their first contact with the electronics in the second half of the second course in the compulsory subject "Electronic Engineering" (6 ECTS). In this course the basics and fundamental principles of analog and digital electronics are set. The ultimate goal of the course is that each student is able to analyse and design electronic measuring systems which involve the sensing of physical parameters, the analog signal conditioning, digital processing and display and data storage. The content of the subject is divided into two main groups:

- The first describes the fundamental components of the analog electronics such as diode, transistor and operational amplifier and an introduction to other measurement systems and analog signal conditioning.
- In the second, circuits and building blocks of digital electronics are studied, as well as combinational circuits, sequential circuits and memories. Finally, the Microchip PIC18F4520 microcontroller is programmed by using high-level language and C18 software. PROTEUS (Labcenter Electronics 7.10) simulation of electronic circuits and development tool MPLAB programming of programmable devices is studied.

The second subject is "Electronic Technology" taught in the first semester of the third year. This is an elective course (4.5 ECTS) which the knowledge acquired in the previous course is applied. The teaching methodology implemented in this course is learning by designing and implementing projects related to electronic aeronautical engineering.

3 METHODOLOGY

In both subjects, the methodology used was similar.

During the first part of the course, teachers have introduced the necessary theoretical knowledge to address the second part of the course: the development of an electronic prototype. Since the subjects are taught in different degrees, some contents are also needed, so in Digital Electronics in the Electronics and Automatic degree the learning units taught are:

- Digital Integrated Circuits.
- Oscillator circuits: Astable, Monostable and flip-flops.
- Synchronous sequential systems. Counters.
- Shift registers.
- Digital Memories.
- Programmable Logic Devices.
- PIC Microcontrollers.

While in the case of grade Aerospace, Electronic Technology, some contents are introduced, like:

- LCD display data.
- Programming and debugging using MPLAB.
- Wireless Communications.
- Serial communication (UART and I2C).
- Control of servos and PWM signal generation using functional unit ECCP (Enhanced Capture / Compare / PWM).
- Programming PC using MATLAB.
- Welding components in a prototype plate.

At the end of the notional units (10 weeks in the case of Digital Electronics and 4 weeks in the case of Electronic Technology), students complete a practical project consisting in the development of an electronic prototype based on a microcontroller.

3.1 The projects

In the case of digital electronics, projects to be performed are proposed by the teachers, leaving the possibility that some of the groups may propose a different project. Thus, the list of projects titles offered or proposed by students was:

- Line follower Vehicle.
- Vehicle avoids obstacles.
- Parking access (*Fig. 1*).
- Control Greenhouse.
- Electronic Dice.
- Weather Station.
- Arm robot.
- Light follower.
- Perpetual Walker.
- Theremin.
- Electronic key.
- Fingers (rock, paper, scissors).
- Remote control light.
- Sorting station.
- Automatic Parking.

Once projects have been chosen, each group must present a block diagram of the hardware and a software flowchart. Both are discussed between the teacher and the group in order to set attainable goals within available time (5 weeks). Then a work plan setting out the time and items to achieve is made.

For aerospace engineers at the end of the first 4 weeks, the student must submit a "feasibility report" project with the contents title, authors, project description, block diagram, budget and references.

Once assessed the memorandum by the teachers of the course, and its viability is accepted, the student moves towards the second part where the project development begins. Over the following weeks (10) and always supervised by instructors, the student develops and implements the different parts that comprise the project. Among the projects we may point out the following one because of its importance and complexity:

- Quadricopter.
- Flying wing.
- Explorer vehicle.
- Recovery rocket system.
- GPS positioning system.
- Hovercraft (*Fig. 2*)

Fig. 1. Parking access prototype

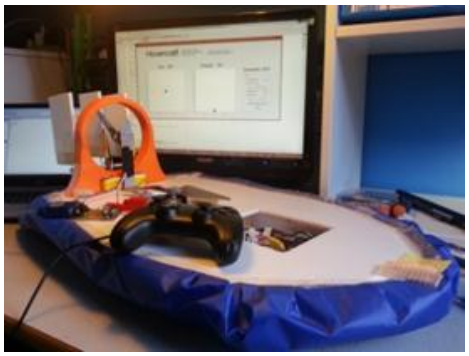

Fig. 2. Hovercraft

3.2 Materialization

During the time period in which the projects are developed, students spend time devoted to theoretical and practical classes to the development of their prototypes. In many cases, even in their free time, they use the labs to work on their projects. During the sessions, they are assisted by their teachers who can tutor them in their doubts and encourage them in their backs.

For the realization of their mounts, they have got the materials needed in the laboratory, both software and hardware. The students of Electronics and Automatic use the prototype microchip PIC16F88 MPLABX platform and plate. For aerospace Eng, MPLAB and Microchip PIC18F4520 is also used.

3.3 Exposition

All work done by students are exposed at the end of the course in a special session [6][7]. The works, accompanied by an explanatory poster, are placed in the Hall of the School (*Fig. 3*) and the students show the necessary demonstration projects to their peers and teachers interested in Electronics..

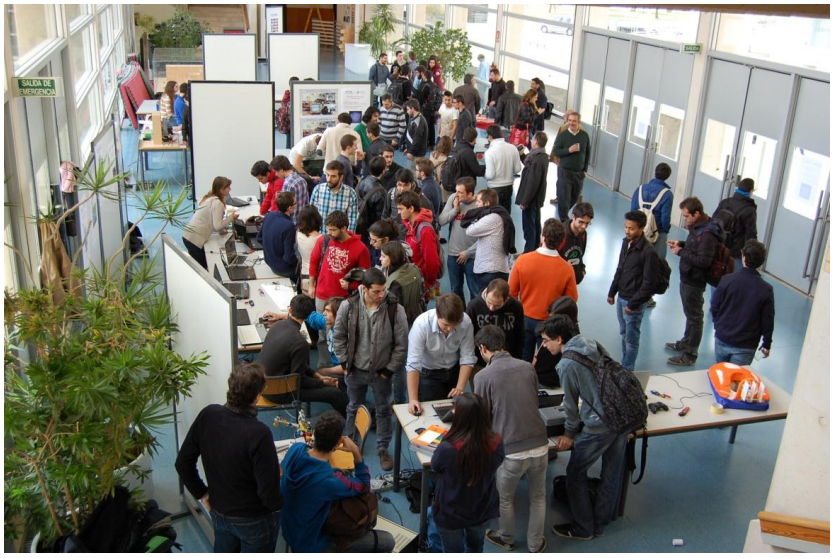

Fig. 3. Exhibition of works in the Hall of ETSID

4 EVALUATION

Undoubtedly, the evaluation of this methodology is the most complex part of the process. Without the possibility of using objective tests we have tried to be as fair as possible. To do this, we used a multiple assessment:

- The teachers of the subject evaluated the work of students in the lab sessions. In this sense, the group's involvement in their project, meeting objectives, the active participation of all team members, task sharing, leadership, etc. is assessed.
- Evaluation by other teachers. During the exhibition, several teachers of Electronics, different from the student tutors, conduct a projects assessment based on items provided by the tutors. So the poster quality is appreciated along the difficulty of the project, the degree of implementation and the presented prototype.
- Evaluation by peers. The students themselves participating in the exhibition, value the work of their peers, filling out a simple questionnaire provided by the tutors. Students value the prototype and the project presentation.

The weight of each assessment system is 50%, 30% and 20% respectively.

The average score for students of electronics was 8.4/10 and 9.3/10 for aeronautics

5 CONCLUSIONS

The teachers of the Department of Electronic Engineering have made a great effort to develop a methodology with the final goal that students gain the knowledge, skills and abilities in the field of electronics sufficiently to adequately enter the workplace. The methodology chosen is the project-based learning.

The student satisfaction is reflected in surveys. Students give their opinion in the section on teaching methodology development. They are collected in Fig. 4 (Aerospace) and Fig. 5 (Electronics). The images are taken directly from the results provided by the university and thus the legends do appear in Spanish and show the students opinion reflects that they agree with the statement “The used methodology and the developed activities during the course help the students to learn the subject”

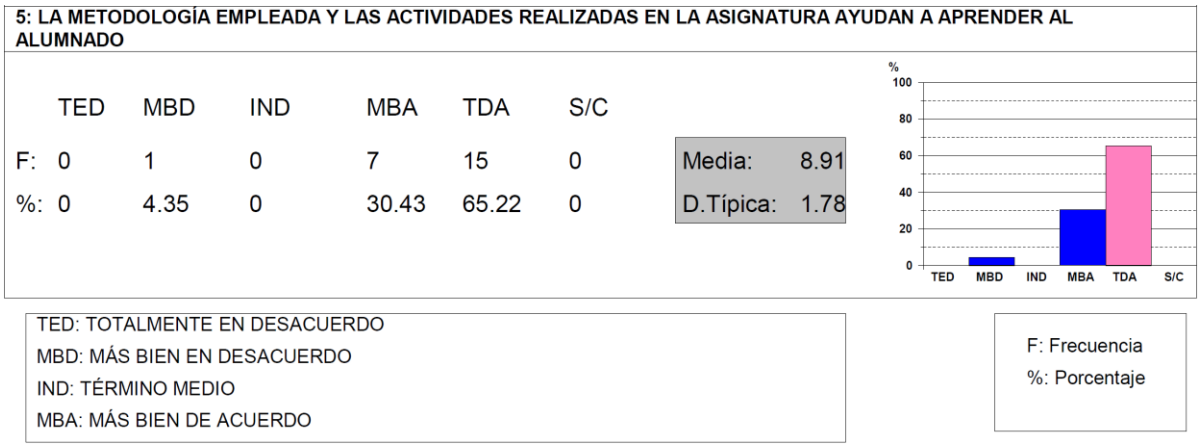

Fig. 4. Survey results in the Aerospace subject

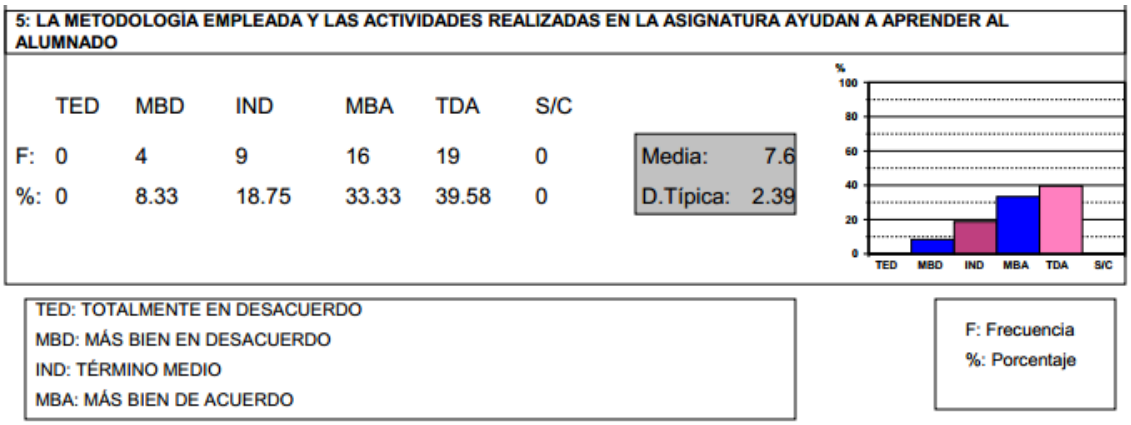

Fig. 5. Survey results in the Electronics subject

Let us note that almost all students agree in their testimony "The effort involved in the subject is worth the level of knowledge and skills acquired," expressed by them at the end of the semester. On the other hand the enthusiasm and commitment on the day of the projects shown puts in place the attractiveness of this methodology.

The course has increased the students' interest in Electronics. This methodology conveys greater confidence and reinforces student self-esteem and prepares them to be able to take on new and greater challenges.

6 ACKNOWLEDGEMENTS

The responsible instructors of the subjects wish to express their thanks to School of Design Engineering (ETSID) in order to provide the showroom required space to align the tables providing an adequate place for exhibitions, panels and grid demonstrators.

And finally we are grateful to the student commitment, involvement and enthusiasm with which we have developed projects once again demonstrating their level of responsibility and maturity.

REFERENCES

[1] Jingxuan Wu, L. F. (2010), Student experience in using Project-based Learning (PBL) in higher education, *6th International Conference on Digital Content, Multimedia Technology and its Applications (IDC)*, pp: 273 - 277.

[2] Solomon, G. (2003), Project-Based learning: A Primer, *Technology and Learning*, Vol. 23, No. 6, pp. 20-30.

[3] Andernach, T., Saunders-Smits, G.N., (2006), The Use of Teaching Assistants in Project Based Learning at Aerospace Engineering, *Proceedings of the 36th ASEE/IEEE Frontiers in Education Conference*, San Diego.

[4] Macías-Guarasa, J., Montero, J. M., San-Segundo, R., Araujo, Á. and Nieto-Taladriz, O. (2006) A project-based learning approach to design electronic systems curricula, *IEEE Trans. Educ.*, Vol. 49, No. 3, pp. 389-397.

[5] Graham, R. (2010) UK Approaches to Engineering Project-Based Learning, *Bernard M. Gordon MIT Engineering Leadership Program*.

[6] http://politube.upv.es/play.php?vid=57840

[7] http://politube.upv.es/play.php?vid=59486