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Teaching Electronics to Aeronautical Engineering Students by Developing Projects

***Abstract*— Teaching electronics to an aerospace engineer with a very limited number of credits has been a major challenge for the authors of this work. This goal has been achieved through a teaching method based on real projects that are closely related to aerospace engineering. Throughout this paper, the process of teaching electronics through two subjects, one compulsory and one elective, is described. Subsequently, a description of the major projects that have been implemented in the last years is performed. The academic results have been very satisfactory, and project development has proved a widely accepted method of teaching by students.**

Index Terms* — *Project-Based learning; aerospace engineering; electronic engineering; electronic technology

INTRODUCTION

It is rather complicated to teach all the electronics contents that an aerospace engineer may need when only a small number of credits is devoted to the task. However, with a proper, direct and effective structure of the contents to impart students may become well prepared in a matter that, in principle, does not correspond to the profile of an aeronautical engineer. In this article, the authors describe how students acquire this preparation through project-based learning (PBL) [1], where students work in groups and carry out the challenges of a real project of electronic engineering applied to aerospace engineering.

A. *Aerospace Engineering Degree*

The degree of Aerospace Engineering is one of the many degrees in Engineering taught at the Universitat Politècnica de València, Spain (UPV). This degree has been taught in the School of Design Engineering (ETSID) since the academic year 2010-11 and replaces the degree of Aeronautical Engineer, which was introduced in the school in 1999-2000.

The degree of Aerospace Engineering has, as most undergraduate degrees, a teaching load of 240 ECTS (European Credit Transfer System) credits over four academic years, divided into subjects devoted to basic education (60 credits), mandatory subjects (88.5 credits), elective subjects (79.5 credits) and a Final Degree Project (12 credits.

Within the module of mandatory subjects of the Aerospace Engineering degree there is a module called Electricity, Electronics and Control covering 18 credits, consisting of three courses: Electrical Engineering (2nd year, 1st semester), Electronic Engineering (2nd year, 2nd semester) and Automatic Control (3rd year, 1st semester), of 6 ECTS credits each of them.

Furthermore, the School offers a large number of elective subjects, among which is the subject of Electronics with 4.5 credits that is taught in the 3rd year, 1st semester. Each elective subject has an admission limit of 25 students.

One of the features of this degree is that it requires a high grade on the entrance exams to college. This fact makes most students have a strong previous education and, above all, a prominent concern in achieving good training to enable them to carry out their work in a complex and competitive discipline, but yet so attractive, such as aerospace engineering.

Subjects of Electronics in the Aerospace Engineering Degree

The Department of Electronic Engineering offers two degree courses in Aerospace Engineering at the UPV:

- Electronic Engineering (6 ECTS), offered in the 2nd year, 2nd semester. It is a compulsory subject where the enrollment limit is 115 students. In this subject, the basics and fundamentals of electronics (analog and digital) are set.
- Electronic Technology (4.5 ECTS) is an elective subject taught in the first semester of the third academic year. The maximum number of students is 25.

With those two subjects, the teachers of electronics have a total of 10.5 ECTS. How to teach all the electronics contents that may be necessary for an aerospace engineer with only 10.5 ECTS?

In the curriculum of this degree, electronics seems to be a rather secondary matter in comparison with more specific areas of aerospace engineering, such as thermo-fluid dynamics, aerospace, propulsion systems, etc.

However, we must keep in mind the general characteristics of students in this degree:

- Good academic record (high cut-off mark for access to this degree).
- Active and restless attitude towards applied knowledge in engineering.

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- Elective subject (Electronics Technology) with a small student number (25) and an apparent willingness to work in electronic engineering tasks.

Given the above, a challenge arises; acquiring knowledge in electronics is a useful and attractive material for students. The solution comes from a teaching method: Project-Based Learning.

B. Project-Based Learning

The Project-Based Learning methodology [2] is one of the most effective teaching methods. It enables students not only to develop the scientific-technical capabilities inherent to the subject, but also to improve their knowledge at organizational and management levels. Besides, it promotes social skills as teamwork, leadership, communication, planning, etc.

This methodology [3-4] is widely used in different disciplines. In [5] Graham publishes the results and conclusions obtained when applying the PBL methodology to engineering education at some universities in the UK. In the field of electronics, some reports have been published where the application of this method to be applied to various subjects exposed both in different Spanish universities [6-7] as well as in foreign universities [8]. Similarly, the project-based method has been tested in the field of aerospace engineering, either describing the need to use assistant teachers in mentoring projects [9], or in the process of design and prototyping (for example, in air stereoscopic display systems [10] or software testing tools for real-time embedded systems [11]). Finally, note that one of the cases where this type of teaching is more convenient is in those studies or subjects with a strong interdisciplinary character [12], as is our case.

The important advantages of project-based learning with respect to traditional education led some teachers of the Electronic Engineering Department (DIE) to apply this method in the electronic subjects of the Bachelor's Degree in Aerospace Engineering at the School of Design Engineering (ETSID) of the Universitat Politècnica de València (UPV).

A *Subject "Electronics Engineering" (Mandatory)*

Students of the Bachelor's Degree in Aerospace Engineering have their first contact with electronics in the second semester of the second academic year in the mandatory subject “Electronic Engineering,” with 6 ECTS credits. Basic and fundamental principles of analog and digital electronics are established in this subject. The final objective of the subject is to teach students to analyze and design electronic measurement systems including physical parameters sensing, analog signal conditioning, digital processing and data display and storage (Fig. 1).

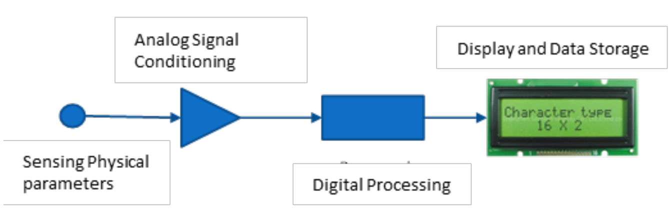

Fig. 1. Block diagram of an electronic measuring system

The program of the course is divided into two main groups:

- The first block includes the study of the fundamental analog electronic components (diode, transistor and operational amplifier), as well as an introduction to analog signal conditioning and measurement systems.
- The second block includes the study of the main digital electronic components and circuits: combinational and sequential systems and memories. In addition, microprocessor /microcontroller systems are introduced in this block. In particular, the basic architecture and some internal peripherals of the microcontroller PIC18F4520 from Microchip Technology Inc. (8 bits) are studied. Students learn to program the microcontroller using the C18 compiler, the MATLAB development environment and the electronic circuit simulation software: PROTEUS release 7.10 from Labcenter Electronics.

B. *Subject “Electronic Technology” (Elective).*

The second electronics subject in the degree is “Electronic Technology,” taught in the first semester of the third academic year. It is a 4.5 ECTS credits elective subject in which the knowledge acquired in the previous electronics subject is applied. The teaching methodology implemented in this subject is electronic project-based learning related to aeronautic engineering. In the following paragraphs this methodology is developed.

The main objective of the subject “Electronic Technology” is to provide students of aerospace engineering with the practical electronic knowledge needed for their professional development by means of the implementation of a project related to aerospace engineering. The 25 students enrolled in the subject are divided into groups of 2 or 3 people so that 9 or 10 groups are formed.

As this subject is 4.5 ECTS credits, students have to attend one class of 3 hours every week. During these 3 hours students and teachers work together in order to solve problems that could arise in the project development. Outside these sessions, students have access to the laboratory as long as it is not occupied.

Over the course of the semester, each group will study, design and implement a project related to aerospace engineering. In order to achieve this goal the subject is divided into the following parts:

First part (4 weeks)

It includes four weeks during which students have to define the project they want to develop and, at the same time, they receive theoretical and practical lessons in order to complete their electronic education. The concepts and applications taught in these lessons are:

- Programming and debugging programs on PIC using the C18 compiler and MPLAB program.
- Data display on LCD.
- Wireless communication.

- Serial communication buses (UART and I2C).
- Control of servomotors and PWM signal generation using the ECCP (Enhanced Capture/Compare/PWM) functional unit of the PIC microcontroller.
- PC applications programming using MATLAB.
- Component soldering on a prototype board.

During these 4 weeks, students select the project they are going to develop. They can choose one of the projects offered by the teachers or they can propose their own project. At the end of the 4 weeks, students have to prepare a “feasibility report” of the project including the following information: Title and authors, project description, block diagram, budget and references.

Second part (12 weeks)

Once the report is reviewed and approved by the instructors, students start the project development. During the next weeks, and always under the supervision of the teacher, students design and implement the different parts of the project. For the development of the projects the PIC18F4520 microcontroller is used, which is a device already studied in the previous electronics subject, and which allows the use of the middle-tier application. The tasks that must be performed are: design, simulation, hardware and mechanics to produce the prototype.

- Simulation. A circuit diagram is drawn through the electronics software package ISIS-PROTEUS (Fig. 2). Subsequently, the electronic circuit simulation is performed in order to check for proper operation. All the design includes a microcontroller PIC18F4520 that is programmed in C language by means of the MPLAB development environment and the C18 compiler. Depending on the characteristics of the project, the microcontroller program can include one of the following parts: analog sensors reading using the A/D converter, digital sensors communication with external devices through an I2C interface, signal processing and filtering, data display on an LCD, actuators control signal generation or wireless communication using a UART interface. Some projects also include the programming of a PC application in MATLAB.

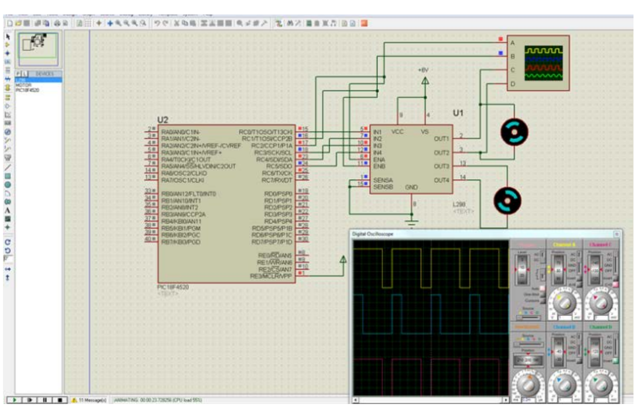

Fig. 2. Simulation of an electronic circuit by ISIS Proteus software

- Hardware. It is the part where students assemble the different components that make up the project:
    - Microcontroller PIC18F4520.
    - Block sensor, which can vary by project (IMU inertial measurement unit comprising accelerometers and gyroscopes, pressure sensors, optical sensors, GPS, temperature, etc.).
    - Other elements such as LCD display, wireless module, brushless and servomotors and the autonomous power supply system comprising battery elements, voltage regulation and filtering.

  To work with the PIC microcontroller the students use a home-designed PCB (Fig. 3), including the micro-controller, the additional circuitry to operate (reset, clock, programming /debugging system and connectors) and connection between the devices and the rest of peripherals of the system.

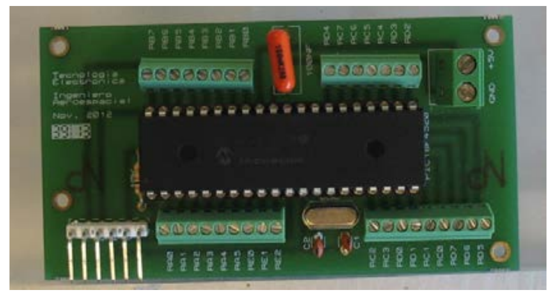

Fig. 3. Home-designed PCB with PIC18F4520

- Mechanics/Manufacturing. Students design and build the physical structure of their project to develop in the subject “Aerospace Manufacturing” that is taught in the same semester, and, therefore, in parallel to “Electronic Technology”.

Public display and report

At the end of the semester, students carry out a public exhibition of their projects (Fig. 4) at the hall of the ETSID, which is suitable for this event, and they deliver a report of the developed work. In this presentation, students show their work to the university community (teachers, students, technicians, etc.) and explain the details of their projects solving any doubt that may arise.

Fig. 4. Public exhibition of projects

Evaluation

The evaluation of the subject is based on the monitoring of the evolution of the project, the student implication in the project and the quality of the project report.

PROJECTS

Nine projects have been conducted in this course, most directly related to aerospace engineering, but also some related to automotive. Here follows a brief description of them, highlighting the parts of the project most related to electronic engineering:

- Quadcopter
- Flying wing
- Explorer vehicle
- Recovery system for a model rocket
- Hovercraft
- GPS positioning system
- Caterpillar Robot
- Graphic display for racing car
- G-force monitoring

A. Quadcopter

One of the most laborious projects was the quadcopter, a four-rotor aircraft for lifting and propulsion. The rotors are placed at each end of a mechanical structure in a cross shape. The project primarily consisted in the electronics design and control to stabilize the aircraft (Fig. 5). The tasks for the PIC18F4520 are reading parameters of aircraft altitude by an inertial measurement unit (IMU) and sending the data to a laptop via wireless communication and receiving stabilization coefficients calculated by the control algorithm to apply to the brushless controllers. A control algorithm performed in MATLAB environment calculates the stabilization coefficients (PID) and sends the signals corresponding to the microcontroller so that it, in turn, forwards it to the engine drives and, this way, it compensates possible imbalances of the aircraft.

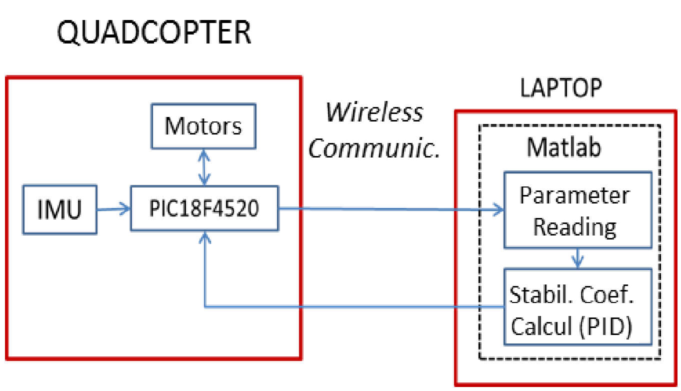

Fig. 5. Block diagram of the control quadcopter

This project has been one of the most complex to develop due to the difficulty of implementing the stabilization algorithm system and the construction of the mechanical structure that houses all the system (Fig. 6).

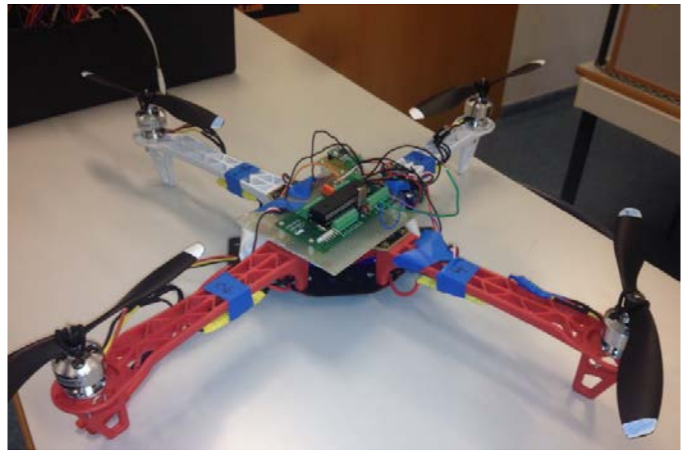

Fig. 6. Quadcopter prototype

B. Flying wing

A second project in the course was to build a flying wing, which is a plane that is characterized by not presenting a conventional fuselage; instead, it is composed entirely of an airfoil structure. This property leads to greater lift force, in order to increase the wing surface, but its flight is also more difficult to control in the horizontal plane due to the lack of vertical surfaces in most flying wings.

The electronic part of the project consisted of controlling the movement of the flaps by means of servomotors and designing and building the electronic circuits needed to control the servomotors and the propulsion motor of the aircraft (Fig. 7).

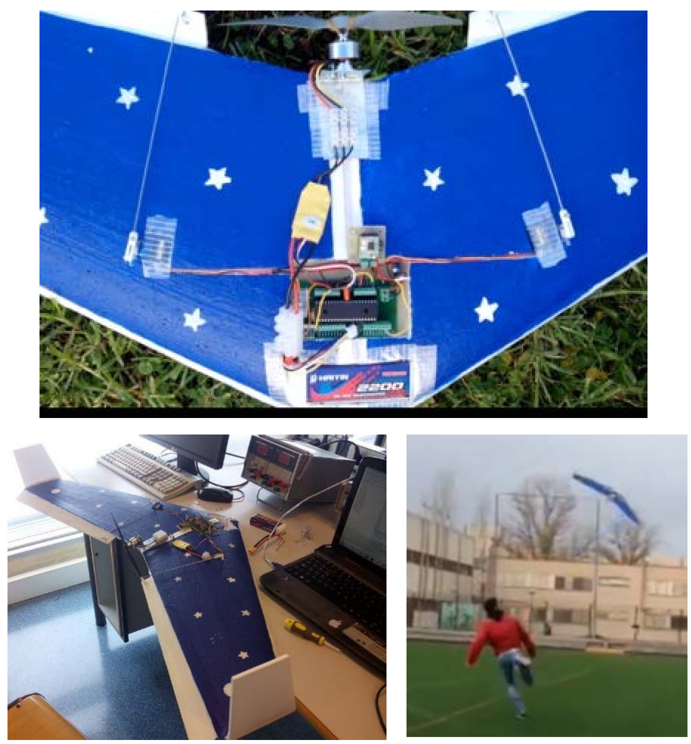

Fig. 7. Design, building and test of the flying wing

The electronic system is composed of a microcontroller, which sets the ailerons position through two servos and the rotational speed of the brushless motor that propels the aircraft by an ESC (Electronic Speed Controller) (Fig. 8). The movement commands of the flying wing are performed from a game controller connected to a MATLAB application. This application collects information from the game controller and transmits the commands by a wireless connection.

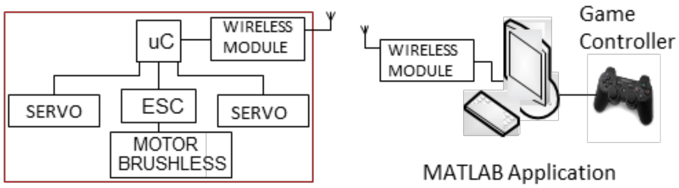

Fig. 8. Blocks system of electronic circuit of flying wing

C. Explorer vehicle

The third project consisted in building an explorer vehicle capable of obtaining pictures and showing them in real time on a laptop. The electronic part of the project consisted in the design of a circuit for the movement and control of the vehicle by an application programmed in MATLAB software (Fig. 9). Two DC motors control the vehicle movement. The microcontroller adjusts the duty cycle of the PWM signal applied at each of them to set the direction and speed of the movement.

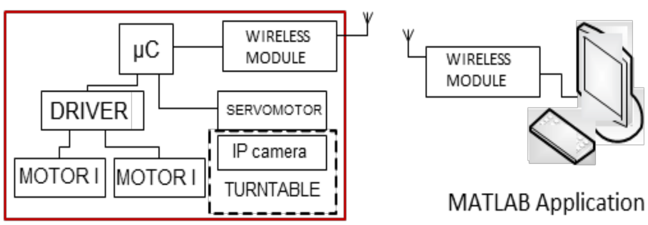

Fig. 9. Block diagram of electronic circuit of explorer vehicle

The vehicle carries on its top a gyratory platform where an IP camera is placed (smartphone) to transmit video by Wi-Fi using the campus network (Fig. 10).

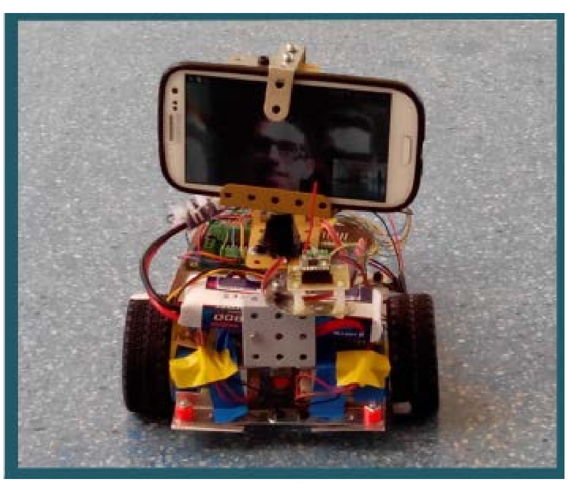

Fig. 10. Building of explorer vehicle

The movement of the gyratory platform is performed by a servo that is controlled by a microcontroller. All actions of the vehicle are coordinated from a MATLAB application, which communicates with the microcontroller by the wireless connection (Fig. 11).

This way, orders of vehicle movement can be made through the tactile surface of a laptop in joystick mode.

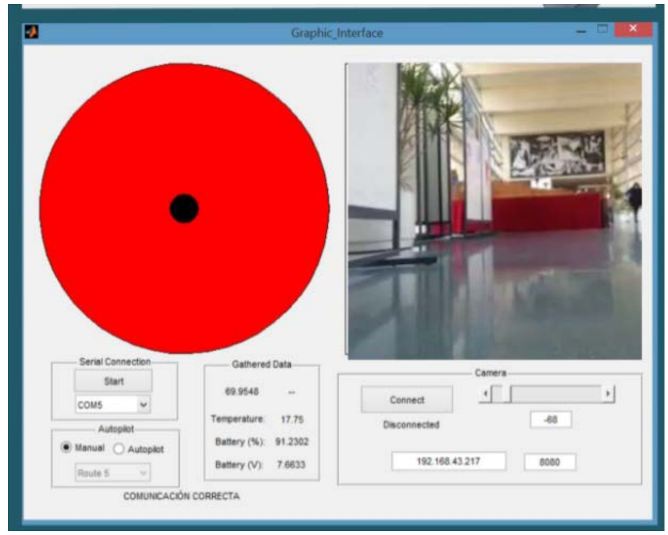

Fig. 11. Control of explorer vehicle

D. Recovery system for a model rocket

This project consisted in developing an aperture system of a parachute for recovery of a rocket when height loss is detected. The electronic part of the project consisted in designing the circuits that read the information of a barometric sensor (Fig. 12) and so determining the height and start of the aperture system of a parachute for recovery of a rocket at the time a height loss is detected.

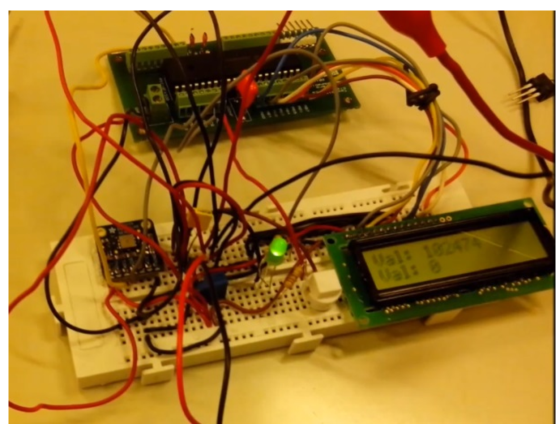

Fig. 12. Circuit for the reading of barometric sensor

Through the measurement of atmospheric pressure, a monitoring of the height of the rocket each 20 ms is established and, when a sudden variation of pressure is detected, the system interprets it as a variation of height and then performs an automatic opening of the parachute (Fig. 13).

Fig. 13. Test of the rocket recovery system

E. Hovercraft

A hovercraft is a vehicle that slides by throwing an air jet against a surface that is below it. This fact generates an air pillow that enables the vehicle to move over any regular horizontal surface without being in direct contact with it. The project consisted in the design of a hovercraft, developing the support system, propulsion and direction by brushless motors and servos (Fig. 14).

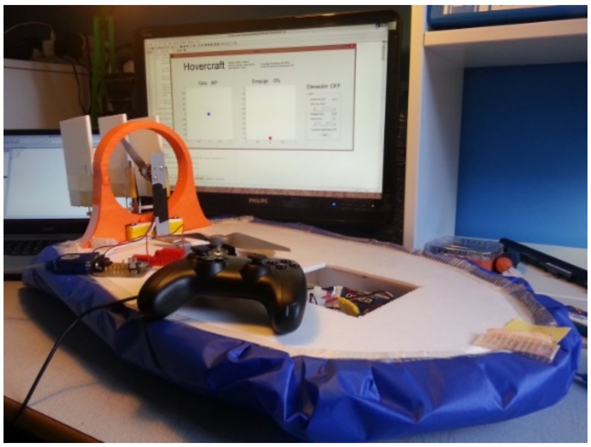

Fig. 14. Design of a hovercraft

The steering control is performed in a wireless way through an application developed in MATLAB that reads the data of a command. The vehicle has two brushless motors, one for support and another for propulsion, whose speed is controlled from a microcontroller by means of an electronic stability control (ESC) system. To drive the hovercraft a rudder is used placed behind the propulsion motor whose movement is governed by a servomotor. The vehicle control is performed by a videogame command connected to the MATLAB application. This application collects the command signals and then they are transmitted via a wireless module to the microcontroller.

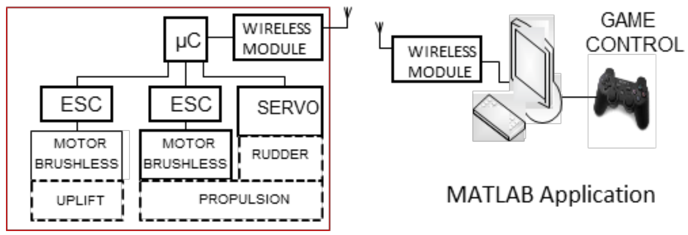

Fig. 15. Block diagram of electronic circuit of hovercraft

F. GPS positioning system

This project involved the design of an electronic system that made a reading of the spatial position of a GPS sensor and sent the coordinates of latitude and longitude to Google Earth through a wireless connection (Fig. 16).

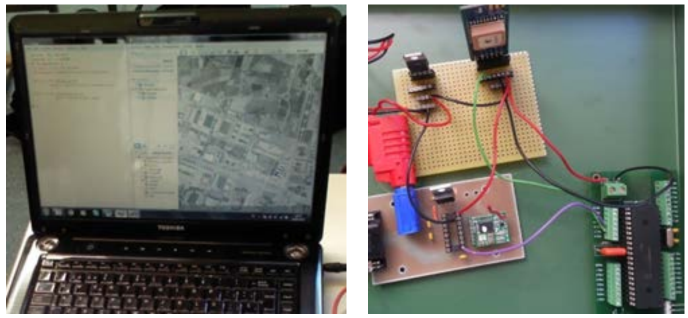

Fig. 16. Design of GPS positioning system

G. Caterpillar Robot

This is a vehicle controlled in a wireless way from a laptop in order to emulate a small-scale of the Rover-type exploration robots that were used in the spatial mission Mars Science Laboratory (Curiosity) in Mars by the NASA (Fig. 17).

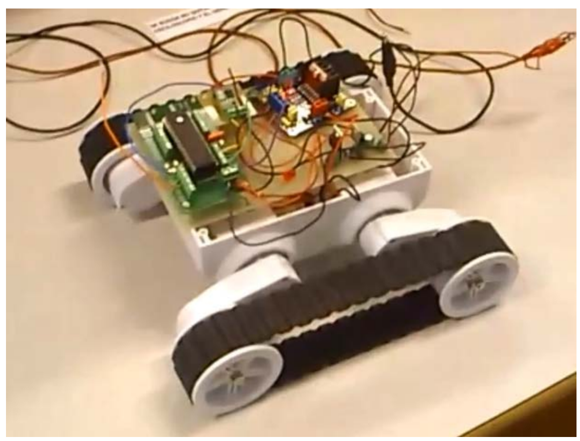

Fig. 17. Caterpillar Robot prototype

The project consisted in a MATLAB application that sends information to the caterpillar robot about the parameters reading by a joystick to control the direction of the vehicle.

H. Projects for the design of a racing car

In addition to the projects specifically related to aerospace engineering, other works have been carried out within the project "Formula Student UPV", which is a motorsport competition that gathers students of universities of all over world in order to design and build a single-seated vehicle similar to the ones of Formula 3. In our case, two projects have been carried out:

Project 1: Graphic display for racing car

The project consisted in designing and building an electronic system for monitoring several parameters of the driving of a car by an indicator panel composed of LED bars of different shapes and colors (Fig. 18).

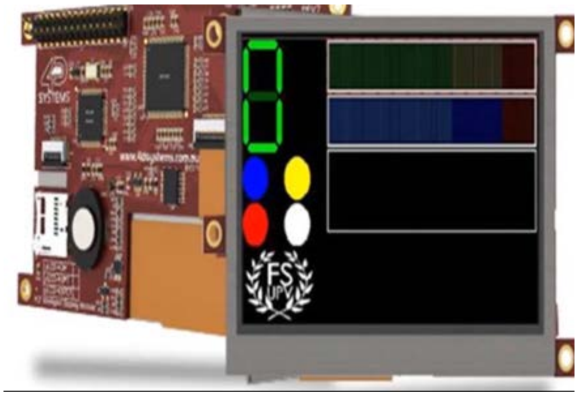

Fig. 18. Graphic display for racing car

Project 2: G-force monitoring

The project consisted in the design of a system to measure the gravity G-force, which is an interesting parameter in the world of motoring competition. For this, an electronic system was built using an accelerometer as sensor (Fig. 19).

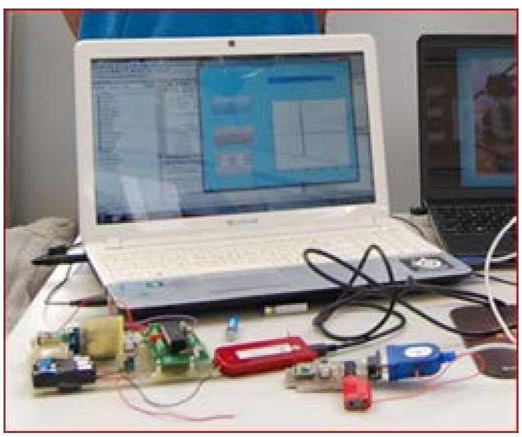

Fig. 19. G-force monitoring

Materials and Development Tools

To perform the proposed projects students have a well-equipped electronics lab, with basic electronic material and a PC with the necessary software to practice with: simulation of electronic circuits by PROTEUS, tool for development of programmable devices by MPLAB and tool of mathematical software by MATLAB for making graphics of user interfaces (GUI).

Next to the electronic laboratory, there is a workshop equipped with several solder stations, revelation of printed circuits boards (PCB), drills, cut tools, etc. where students can implement basic assemblies.

One of the goals of the subject is to maximize the skill of students to resolve the problems that may arise in the development of engineering projects. For this, the tools available must allow the development of the projects proposed by the students but, at the same time, the tools must have some limitations to maximize the creative skills of students and force them to face the difficulties that can appear in the development of real systems. In this sense, tools like the Arduino platform were discarded because the design task is reduced to assembling prefabricated hardware modules and to programming using libraries, without students knowing exactly how the elements that they are using actually work.

Repercussion of the Projects

Throughout the process of performing these projects, students achieve a high capacity to design, develop, implement and test electronic systems, getting a level of knowledge and aptitude that the majority of them did not imagine at the start of the course. It is noteworthy that, as these subjects are within a degree that is not aimed at the design of electronic circuits, students were not aware of the tasks they would perform when the course started.

Presently, almost all students that begin a university technical degree usually have knowledge of informatics and of telecommunications at user level; also, they tend to have basic knowledge of electricity applied to the domestic sphere, but electronics is precisely a field too unknown to them. Nowadays, it is not easy for the user to have access to the information of the electronic equipments because devices are becoming increasingly miniaturized and hence their characteristics are more hidden. That has been the main goal proposed by the instructors who teach the subjects of this paper: to discover electronics to students of a technical degree not specifically focused on electronics, in our case aerospace engineering.

Conclusions

In the two electronic subjects of the degree in Aerospace Engineering at the UPV, the instructors (Department of Electronic Engineering) have made a big effort to develop an agenda and teaching methodology whose goal is to make students of both subjects acquire enough knowledge, skills and abilities in the field of electronics to function properly in the difficult world of aerospace engineering. The selected methodology is project-based learning because its teaching advantages have been checked.

The academic results reached by students who took the subject “Electronic Technology” during the academic years 2012-2013 and 2013-2014 can be considered as a big success. The satisfaction of students is reflected in the surveys of opinion, where in the question corresponding to development and methodology of the teaching, they valued it two points above the average of the rest of departmental subjects (Fig. 20).

Besides, it is noteworthy the enthusiasm and compromise of the students while developing the projects, which reached its zenith the day of the public presentation of the same. The students showed great interest in the task, working many more hours than the ones established in the courses' credit load, developing complex and sophisticated projects and showing big creativity, motivation and work capacity. In reference [13] can be seen a video-abstract of these projects and the public exposition developed in the subject "Electronic Technology" during the year 2012-2013.

In the evaluation survey completed by the students about the instructors' activities, in the item where they evaluated if the methodology employed and activities made helped them to learn, the score achieved is 8.91 points over 10.

Fig. 20. Rating of students about the methodology used in the subject "Electronic Technology". Question: "THE METHODOLOGY USED AND THE ACTIVITIES PERFORMED IN THE SUBJECT HELP STUDENTS TO LEARN". TDA: TOTALLY AGREE / MDA: ROUGHLY AGREE / IND: INDIFFERENT / MBD: ROUGHLY DISAGREE / TEA: TOTALLY DISAGREE

It is also noteworthy that not all students that want to enroll in this subject can do so, because there is a limit of 25 students and only those with the best marks can make it. Thus, a group of high performance is achieved.

Students have developed at the end of the course not only curriculum capabilities inherent to the subject but many social skills, among which are included cooperation, coordination and multidisciplinary organization, which supplement and complement their university training as engineers and so they achieve a better preparation for the working world. This methodology stimulates and increases the competitiveness between different groups, increasing the level of commitment and self-demand.

Virtually all of the students agree in their testimony after completing the course "compared with the level of knowledge and skills acquired, the effort made in the subject was worth". This methodology generates confidence and strengthens self-esteem of students; they feel ready and able to take on new and greater challenges in the future.

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REFERENCES

[1] G. Solomon, "Project-Based learning: A Primer," Technology and Learning., vol. 23, no. 6, pp. 20–30, Jan. 2003.

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

[3] Markkanen, H., Donzellini, G. and Ponta, D., "NetPro: methodologies and tools for Project Based Learning in Internet," World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED-MEDIA 2001), Chesapeake, VA, pp. 1230-1235. 2001.

[4] Ponta, D., Donzellini, G. and Markkanen, H, "NetPro: Network Based Project Learning in Internet," European Symposium on Intelligent Technologies, Hybrid Systems and their implementation on Smart Adaptive Systems 2002, Albufeira, Portugal, pp.703-708. 2002.

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

[6] J. Macías-Guarasa, J. M. Montero, R. San-Segundo, Á. Araujo, and O. Nieto-Taladriz, "A project-based learning approach to design electronic systems curricula," IEEE Trans. Educ., vol. 49, no. 3, pp. 389–397, Aug. 2006.

[7] Arias-Pérez-de-Azpeitia, M., Fernández-Linera, F., González-Lamar, D., Hernando, M., Rodríguez, A., "Influencia del aprendizaje basado en proyectos en asignaturas de diseño de sistemas basados en microcontrolador.", TAEE, 2010.

[8] R. Hong Chu, D. D. C. Lu, and S. Sathiakumar, "Project-Based Lab Teaching for Power Electronics and Drives," Education, IEEE Transactions on, vol. 51, pp. 108-113, 2008.

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

[10] Dabipi, I.K., Hartman, C.E., Burrows-McElwain, J.B., Mohseni, S., "Design and Construction of A Stereoscopic Aerial Imaging Platform: A Project-Based Platform for Teaching Freshman Engineering Students", 38th ASEE/IEEE Frontiers in Education Conference, Session F4C, 2008.

[11] Loubach, D.S., Nobre, J.C.S., da Cunha, A.M., Dias, L.A.V., Nascimento, M.R., Dos Santos, W.A. "Testing Critical Software: A Case Study for an Aerospace Application". 25th Digital Avionics Systems Conference, 2006 IEEE/AIAA.

[12] Gonzalez-V, J.L., Loya-Hernandez, J.E., Project-based learning of reconfigurable high-density digital systems design: An interdisciplinary context based approach". Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports, 2007. FIE '07. 37th Annual

[13] Video-resumen de los proyectos y de la exposición pública que se desarrolló en la asignatura "Tecnología Electrónica" del año 2012-2013 http://politube.upv.es/play.php?vid=57840

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