

Successes and challenges of a Collaborative-PBL Program in Engineering Degrees

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Abstract

This paper presents an extracurricular program called INSPIRE3 that has been implemented by the ETSEIAT (Escola Tècnica Superior d'Enginyeries Industrial i Aeronàutica de Terrassa), a center belonging to the UPC-BarcelonaTech (Universitat Politècnica de Catalunya). This program is mainly aimed at facilitating cross-curricular skills and developing abilities among students through collaborative-project based learning. The projection of an attractive external image of engineering degrees offered by ETSEIAT in order to increase the enrollment in such degrees is a secondary goal of this program. Under INSPIRE3, several real, challenging and multidisciplinary engineering projects are currently under development. The main feature of this program is that the subjects of the projects are proposed by the students themselves. In this paper, INSPIRE3 motivation, program management and implementation process are described and a short description of projects under development is also given.

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1. Introduction

The implementation of the European Higher Education Area (EHEA) requires the fostering of cross-curricular skills and the development of abilities such as critical thinking, communication skills, leadership, project and budget management, negotiation, team-work, etc. It is obvious that these kinds of concept cannot be taught and learned in the same way as the previous EHEA-era “regular” subjects. The traditional teaching approach focused on the lecturer rather than the student often leads to some disappointing results among the most vocational students. The change from traditional procedures to the new student-focused approach represents a major challenge in the design of the curricula for EHEA degrees.

On the other hand, the decrease in the enrolment of new students in Science or Engineering degrees is a well known occurrence in developed countries. In fact, in the last 8 years, enrolment has been reduced by almost 23% [1]. Several reasons can explain this. First of all, the culture of effort among youth has been sadly displaced by “easy success”, especially when engineering studies are perceived to be “too hard and too long”. This is the most important reason, because it results in the most able high school students preferring “easier” studies, such as economics, law or business management rather than engineering or sciences degrees. In the second place, the

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difference in income between graduate and undergraduate staff has been substantially reduced [2-4]. All these phenomena can be seen in industrialized countries (U.S., Europe, Canada, Japan, etc.). The reasons cited above suggest that the origin of the problem is a society misperception of what is involved in the training of professional engineers as well as a general misunderstanding of the actual activity or professional profile of engineers.

In seeking a solution to this problem, both regional and national governments in Catalonia have already reacted with some initiatives, such as a five-year mentoring program, called Enginycat [5], of which the main objectives are:

- Improving the level of scientific and technical education students in the pre-university stage.
- Increasing the demand for engineering studies, with special emphasis on the presence of women and on the prevention of drop-out during the first years.
- Contributing to academic outcomes improvement.

Meanwhile, in recent years, public universities managers have recognized the importance of promotion and recruitment policies as a basic tool to successfully combat the enrolment reduction.

In order to face the above mentioned challenges, the INSPIRE3 program has been created and developed in the ETSEIAT. This program provides an opportunity to educate vocational students through an innovative teaching method that enables collaborative learning based on the implementation of real technology-based projects. INSPIRE3 encourages an entrepreneurial spirit, as well as cross-curricular skills and the development of abilities.

2. Guidelines of INSPIRE3 program

The originality of INSPIRE3 lies in developing real technology-based projects. An important feature is that project subjects are proposed by student groups themselves. It is a requirement that project proposals must be challenging [6-9]. It is important to note that the role of the academic staff is not to lead the project, but to supervise the work tasks and to act as reviewers, advisors and/or counselors. In this way, students' ownership and leadership of the project can be ensured. Finally, it should be emphasized that participation in INSPIRE3 is completely voluntary and outside the official academic curriculum. However, activities conducted under this program have an academic recognition.

A key point for the success of this program is the management and retention of knowledge gained through development of the projects, in order to provide continuity even when the students' training period ends and the persons involved leave the Faculty. It is compulsory for all groups to incorporate some younger new members every year, to ensure that knowledge is transmitted from one student generation to the following one.

Participation in the program becomes an excellent opportunity for completing the training of students, applying knowledge gained through study, for personal growth and, ultimately, to improve personal abilities for subsequent immersion in the professional environment market. The motivation to participate in INSPIRE3 projects is diverse. However, we have noticed that a common feature is an enthusiasm for work and the firm conviction that this type of activity is an extremely powerful learning tool [10-12].

3. Outcomes of INSPIRE3 program

As has been mentioned before, the INSPIRE3 program is mainly intended for soft and professional skills development among students of engineering degrees. However, this program also addresses the issues mentioned below.

- It provides a differentiated and innovative external image for the ETSEIAT, by fomenting in society a change in the perception of engineering studies and of the activities of professional engineers.
- Streamlining the relationship between students and professors in order to meet the aspirations of the most enthusiastic students and to avoid the disappointment related to conventional methods.
- The promotion of human and personal values among students (initiative, talent, entrepreneurship, innovation, ...)
- Students' loyalty, of those remaining in the school and of recent graduates, maintaining and updating the link between the participating groups and their projects, even when research is completed.
- To identify motivated students, both in applied engineering research or as possible Masters students.

- To strengthen the links between the university, external agents and society.

3.1 Project development

INSPIRE3 teams are constituted when the main objectives and work plan of each team are well defined, and when resource needs and processes have been identified, in order to search for collaboration agreements with university and society entities or associations. All these aspects have to be presented and defended by each team in order to be supported and granted by external institutions and companies.

As regards the ambit of the project, it is possible to identify several steps (prototype construction, CAD 3D-CAE, materials or process studies and search, simulation study or electronics behavior, etc), while during project development a presentation at scientific or technological contests or events can be envisaged.

3.2 Training elements

Commitment requirement has been considered as a formative action for INSPIRE3 team students or project members. Other training aspects involved in INSPIRE3 working groups is the interest of being part of a working group, the enthusiasm to define a project or to join it as a group member, and finding the best way to contribute to the development, the desire to participate in decision making... It also requires the ability to take the consequences of adverse outcomes and to recognize the purpose of the effort expended in finding solutions, and it is intended to include an interaction with students from different courses and university networks with the same objectives, for the creation and development of interdisciplinary projects.

The promotion of interactive teaching methods and the management and retention of knowledge are focused on project work as a key aspect of the program's success. For this reason, INSPIRE3 program implements mechanisms to ensure the retention of knowledge.

The academic community of ETSEIAT is committed to providing both financial and material support such as logistics, by allowing the use of space and equipment located in the laboratories in several departments. At present, up to 15 staff members of the ETSEIAT support student projects by providing technical advice, equipment and access to some particular facilities, such as wind tunnels, composite materials laboratories, research laboratories, etc.

The incorporation of new students every year will strengthen the project, by establishing a flow of knowledge between oldest and newest participants. In this way, project continuity is ensured and therefore greater efficiency in managing the resources invested. It should be noted that a prime requirement is the successful fulfillment of regular academic activities.

3.3 Ongoing project results

Equip Trencalòs: This was the starter group of INSPIRE3. It began its activity in 2007 with the participation of 7 students in order to participate in the competition AirCargo Challenge 2008. In this competition, an air cargo model airplane had to be designed and built according to certain technical specifications. The activity of this team has led to several appearances in the media (TV3, print and radio) and to participation in events related to the aviation industry. Currently there are 21 students involved in the following projects:

ACC2011: continuation of the original activity of high-performance model aircraft design in order to participate in competition AirCargo Challenge 2011 (Fig. 1).

UAV Trencalòs: the purpose of this team is to develop an Unmanned Air Vehicle from scratch. The core knowledge of this project is the development of autonomous navigation control. At present this project is in the implementation and sensors calibration stage.

Solar Endeavour: This team has designed and manufactured a solar-powered model aircraft in order to be used as a range-extended surveillance vehicle.

JET (Joves Enginyers Terrassa): The goal of this student association is to coordinate and plan events and manage projects of a certain size to facilitate and complement the skills and competencies of leadership, communication, teamwork, etc. This association has organized two editions of the JET Robotics Competition (CRJET), which is an international contest of robots competing in the following categories: sumo and mini-sumo, line-trackers and free design. A specific call for participation was addressed to high-school students in order to

promote interest in engineering among teenagers. The success of the initiative led to the implementation of robotics courses aimed at pre-university students. The activity was broadcast live on the Internet. The CRJET has appeared frequently in the media (TV3, radio and press). The website of last year's competition received over 20,000 hits, 8,000 of them on the day of the contest in order to follow it live. (<http://www.youtube.com/watch?v=Vav2nFLhhjY> CRJET10).

UPCecoRacing: (<http://www.ecoracing.es>) This refers to a team of 12 students who designed and built a single-seat hybrid racing car in order to participate in the Formula Student competition. At present, it is the unique European Formula Student car with hybrid (petrol/electric) propulsion. For this reason, this pioneering initiative has had a significant impact in the media (TV and press). Students involved in this project have faced an engineering challenge in which they must apply a range of knowledge acquired during their studies, such as vehicle technology, mechanical systems, internal combustion engines, electrical systems and electronic control systems, etc. On the other hand, Formula Student is a multidisciplinary competition that includes not only purely technical aspects but also other skills such as project management, budget management, negotiation, strategy, teamwork and team building, etc. (Fig. 2).

We CanSat Team. The goal of this team is to design and manufacture a small satellite whose size is limited in order to participate in international student contests. They participate in the “Come Back” category. In this category, the CanSat is launched with a rocket up to an altitude of 1,000–2,000 m. During the descent flight a specific mission must be conducted. The vehicle must land at a certain predetermined point. For this reason, it has a GPS and a control system to drive it to the target. There are 8 students involved in this project.

Near Space Laboratory (NESLAB). The goal of this team is to develop space research and Earth observation missions using stratospheric helium balloons in order to realize a cheap and reliable access to space. There are 12 students involved in this project. Specific issues of this project are: mission control, on-board electronics, data-collection, radio transmission. The vehicle was equipped with a high resolution digital camera (21Mpixels), specific sensors of temperature, pressure and altitude, a GPS receiver and a radio-beacon. The vehicle and the on-board electronics were designed to withstand the extreme stratospheric conditions (pressure, temperature, humidity, etc). (Fig. 3)

Rocket Laboratory. (ROCKLAB). The goal of this team is to acquire knowledge and experience in rocket engineering. They have already developed a supersonic rocket (1.2 Mach) that took part successfully in an international student contest. Specific issues of this project are: mission control, on-board electronics, data-collection, radio transmission, composite materials, aerodynamics, propulsion, structures and manufacturing processes. There are 12 students involved in this project.(Fig.4)



Fig. 1 ACC2011 airplane under construction



Fig. 2 Official presentation of ecoR2 racing car at UPC premises



Fig. 3 Picture taken from 23km of altitude



Fig. 4 Design of Rocklab I

4. Conclusions

The INSPIRE3 project has been revealed as an innovative teaching method for engineering studies and an excellent tool to attract students. The program addresses two problems: the development of skills and abilities in engineering degrees, and society's misperception of engineering studies and professional activity. The project has been demonstrated to be a successful tool for the promotion of skills and the development of abilities, according to the European Higher Education Area (EHEA). It also contributes to correcting the distorted perception of the difficulty of engineering studies. At present there are about 85 students involved in 9 projects, this extent of participation being particularly indicative of the excellent response of this initiative.

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