ELECTIVE PROJECT COURSE: REALIZING THE ACADEMIC INTERESTS OF STUDENTS

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ABSTRACT

Even before entering to university and during their engineering studies, many students have personal interests related to different areas, which are not necessarily covered by the theoretical or practical courses. These topics of interest to students are a great opportunity to start working as projects, even from the first years of the program and with the help and support of some professors, they would contribute to strengthen their skills as engineers. Electronics Engineering program at the Pontificia Universidad Javeriana, Colombia, decided to open an elective course called Special Projects on Electronics Engineering, in which the students, with the guidance of the professor, define the projects to be carried out under the CDIO approach. Through the process of conceiving-designing-implementing products, processes, and systems; students develop a project of their own interest related to electronic engineering. The idea of this course was originated as an alternative of academic recognition of the work done by the students linked to the research groups. Currently, the class has been structured in such a way that at the end of the course students must submit the functional prototype of their project, attaching to document, tutorial, video or poster to socialize and give visibility of the work done. The document is structured as follows: first, it details the structure of the course and the learning outcomes. Then, the methodology and the competencies that will be developed are shown. After that, the projects of some students are presented. Finally, lessons learned, and conclusions are given.

KEYWORDS

Engineering education, project-based learning, educational innovations, collaborative learning, active learning, Standards: 7, 8.

INTRODUCTION

Student Research Groups have as one of their objectives to link undergraduate students in the development of research activities, in order to develop research skills and abilities. Despite the enormous work they do in their free time, in order to carry out projects and keep these groups functioning, the students do not obtain any recognition in academic credits.

From this situation, we looked for ways to offer academic recognition to these students for their work and we had the idea of creating an elective course. Initially, this class was designed for the students belonging to these research groups so that they could carry out their work and also have recognition of academic credits.

After submitting the proposal of the new class to the School Council, including syllabus and methodology, the new course on Special Projects in Electronic Engineering was approved, which was offered for the first time in January 2017. This course provides engineering students

with spaces and support to develop projects of their interest that are related to electronic engineering.

Although this class was born with the idea of offering credit recognition for students linked to research groups, after the first version, several engineering students who want to develop projects on a specific topic that is not necessarily covered by the courses of their academic program or in the research groups, asked to take this class.

Elective courses could be an alternative to provide students with a space to develop projects of their interest, especially projects related to their career, and with support of classmates of higher semesters, professors or even graduate students.

Special Projects on Electronics Engineering gives students the opportunity to put their knowledge into practice and foster the development of skills (personal and interpersonal), such as collaboration, team work, creativity, problem-solving, critical thinking, communication, and responsibility.

Electronics Engineering program at the Pontificia Universidad Javeriana program had been involved in a curricular review towards the implementation of the CDIO approach (Garcia, et al. 2014). The methodology of this elective course is based on CDIO approach. Through the process of conceiving-designing-implementing products, processes, and systems (Crawley, et al. 2014); students develop their projects.

Special project in Engineering syllabus's is integrated learning experiences that lead to the acquisition of disciplinary knowledge and skills (CDIO Standard 7), using project-based learning -PBL- (Gunnarsson, et al. 2012) and active learning (CDIO Standard 8). This strategy involves students, as active participants, in their own learning process (Garcia, et al. 2014). Active learning help students make better connections among concepts and facilitate the application of this knowledge to complex, contextualized, and real problems (Crawley, et al. 2014).

This paper presents a description of this elective course and the applied methodology. This document wants to show how with the work of a few teachers concerned and interested by their students, students can be actively involved and motivated to learn more about their engineering program, developing projects that until now had not found a space, resources or an accompaniment to make them.

Compared to previous publications dealing with project-based learning the key points of this paper are that students can propose project tasks themselves and that the participants in the course can be from different years.

The document is structured as follows: first, a description of the course Special Projects on Electronics Engineering is provided. Then, the methodology and the competencies that will be developed are shown. After that, the projects of some students are presented. Finally, lessons learned and conclusions are given.

DESCRIPTION OF THE COURSE

Special Projects on Electronics Engineering is a theoretical-practical elective course of two academic credits (these two credits are equivalent to 3 ECTS). These credits correspond to one or two hours per week of work in the classroom with the accompaniment of a professor and four or five hours of independent work. Our academic period has 18 weeks, including two weeks of final exams and final projects.

Over each academic period the number of students has varied between 12 and 20 by each class, up to two different classes. time the course has been given. During the course the

students are free to organize in groups from two to six students. It depends of the complexity of the project. Each project group has access to several technical experts.

Course Special Projects on Electronics Engineering was created as an alternative to the academic recognition of the work done by students linked to research groups, initially the Robotics Group (Bravo, et al. 2017), who demonstrated commitment and dedication of time in the development of their projects. Initially, the only requirement to enroll in this course was to be an active member of a research group. However, it is now available to all students of the engineering school. Mainly students of Electronics Engineering attended this elective course, also we have had a couple of students from Systems Engineering and Industrial Design.

In the course Special Projects on Electronics Engineering, students from different semesters can develop a project of particular interest that is not included in the core courses of the curriculum. The course provides students with conceptual and technical bases that help them in the planning, development, documentation, and execution of technical or research projects. Additional to the professor of the class, students can have the tutoring of professors and graduate students with expertise in the topic of the project.

At the end of this course, students should be able to:

- Integrate knowledge acquired in previous courses by developing a project related to engineering electronics that is of interest of them, under the guidance of a professor.
- Practice processes of conceiving-designing-implementing products, processes, and systems in the development of an engineering project.
- Apply engineering skills, such as, system thinking, measurement technics, comparison between theoretical and practical results, trouble shooting.
- Apply personal and professional skills and attributes, such as, problem-solving, creativity, collaboration, responsibility and communication (oral and written).

METHODOLOGY

The methodology of the course is based on the CDIO initiative and project-based learning (PBL). PBL is a learner-centered pedagogical strategy seeks that the students participate in the planning of a project, investigate and apply new knowledge and skills in the solution of a problematic (Bender, 2012), as an example of active learning (CDIO Standard 8).

Through the process of CDIO, students develop their projects, in such a way that in addition to acquiring knowledge and putting them into practice, improve their group work skills, develop their critical thinking and their communicative skills both written and oral (CDIO Standard 7).

Following, we describe the stages to develop the projects in this elective course (Hwang, 2017):

Preparation stage

This stage has two purposes; the first one, students introduce themselves to each other, it is necessary because, students are from different years or even programs. The second one is each student show and share project topics in a brainstorming of ideas to work, and have their first oral presentation, giving details of the work they wish to do in class. Sometimes students do not have a project in mind, so teacher give them some ideas of engagement projects to do.

Whole class evaluates each project. In this evaluation, aspects to be taken into account, suggestions, new ideas, possible difficulties and previous experiences in the subject are mentioned. Students of all ages, freshmen to senior can be in this class, thus the level of experience and knowledge is quite heterogeneous. Usually the best-structured projects are those belonging to the research groups, since the Conception stage has been carried out previously.

After that, students can find other colleagues who share the same interest for a topic or other proposals that call them more attention. It allows students create new alliances and reorganize their workgroups. It is desirable that students work in a workgroup. However, there are cases that there is only one student interested in a specific topic. In these cases, the student decides if he or she wants to work alone or if he o she wants to join another project that catches his/her attention.

Some professors with expertise in the topics of the project are invited to participate in this discussion. Finally, work groups are organized freely, to begin to define and limit the project to be carried out.

Conception stage

The purpose of this stage is the conceptualization of the project. Once the students have selected the problem they want to solve, they develop a report with the description of the problem, the methodology to arrive at the solution, the resources they need, the deliverables and the work schedule. Also, they must add a paper, taken from a formal publication, related to the topic in which they will work.

Among the deliverables are functional prototype and a document, tutorial, video or poster to socialize and give visibility to the work done. In this stage of formalization of the project, the professors advise the students in the structuring of a project that can be developed and delivered finalized in the academic semester. This stage allows students to be trained in specific aspects of the methodological process of a project.

Design stage

The purpose of this stage is to establish the project requirements and develop a design that meets these requirements. Under professor guidance, students are responsible for acquiring the knowledge and skills necessary to solve the problem or the selected need. Although the members of the work groups are students of different semesters, each student gives their contributions from their experience and knowledge.

Projects have involved some topics different to electronics, such as, mechanics, aeronautics, chemistry, etc, so students must to start to keep in touch with students and professors of other disciplines.

Each group must to share the design progress once a week. Professor can pick one of the students of the group to present the design status. They must present the design to the whole class to receive the feedback and the respective comments, as well as to answer the questions of their other classmates.

At the beginning, this stage is evaluated but not graded. Once all the questions or problems have been answered and corrected to the classmates or the teacher, the group will have its grade.

Implementation stage

In this stage, the students implement and test the proposed design. Students have 7/24 access to the workspace.

As part of evaluation, a different member of the group must present the progress and the status of the projects once a week. Problems presented during the implementation stage are discussed between the students of the class and the teacher. This is done so that everyone knows everyone's problems and learns from their colleagues or can give solutions.

If there is a topic that needs to be applied, but that is unknown to a large part of the students, the teacher explains part of this topic, so that all students can understand it.

Student must do all the tasks that lead to the project result.

Operation stage

This stage involves demonstrations of the prototype. It allows students to understand their prototype run in the real world. Additionally, they can obtain feedback from users and experts.

As part of the final evaluation, they must present their project at a fair for electronic students, named Expoelectronica, at the end of the semester.

In this fair, they must show their project, sharing their achievements to the visitors, who are students of different programs, but they must also make a formal presentation before an external jury, who will evaluate them.

Presentation and evaluation stage

Before to go to the fair, students must expose to their colleagues and professor, the development, evolution and outcome of the project. Also, they must to present the technical documentation and final report (poster, article or video).

The professor of the course monitors the project progress in two ways. The first is through the weekly presentations of the progress that students have of their project in the classroom. These presentations allow students to know the projects of their classmates, who can contribute with ideas, comments and, suggestions. The second way is to review the binnacle that students report their work. Additionally, students can meet with the professor during student attention hours to show their current work status and request some advice. The student attention can be face-to-face or remotely through google hangouts. Students may also request the assistance of an expert in the topic of their project.

DEVELOPED PROJECTS

The projects developed in the course can be proposed by students, by a research group, or a professor. These projects can be technical or research and can be divided into the following categories:

- **Hardware**: In this category falls projects related to the design, construction of artifacts and mechanisms. Some developed projects are:
    - *Unmanned aerial vehicle (UAV) with solar panel for powering servomotors*.
    - *Multi-receiver radio frequency lights*.
    - *Plotter*. *(See Figure 1).*

Figure 1. 2D Plotter

- *Sumo and minisumo robots*. (*See Figure 2).*

Figure 2. Students group (different years) in an International Sumo Robot Tournament

- *Robotic hand. (See Figure 3).*

Figure 3.Robotic hand

- *Access control systems.*
- *Quadcopter.* (*See Figure 4).*

Figure 4. Quadcopter

- *Identification system and decision making using Pixy camera. (See Figure 5).*

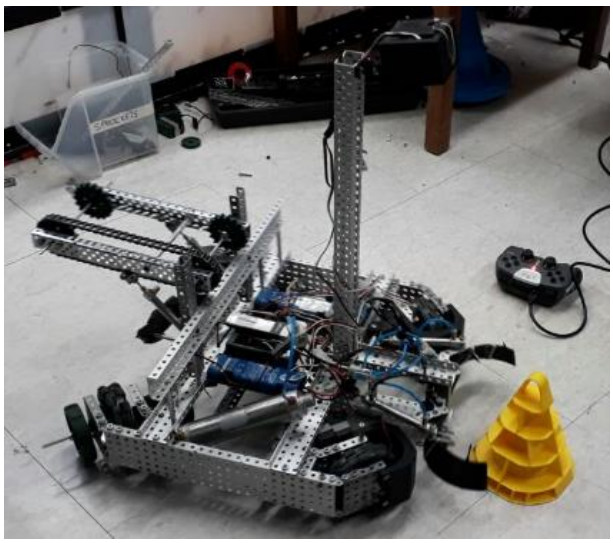

Figure 5. Robot with Pixy camera

- **Software applications**: It mainly includes the development of software applications. Some of the developed applications are:
  - *Bluetooth alert and search system*.
  - *Mobile application for robot control by Bluetooth*.
- **Education**: This category covers projects that develop guides and tutorials for educational purposes. It also includes projects related to the design educational activities using technological tools, such as robots. Example of developed projects include:
  - *Discovering renewable energies using Lego Education Renewable Energy kit*:
  - *Storytelling with animatronic characters*. (*See Figure 6)*

Figure 6. Animatronic characters

  - *Video for the construction of a test mobile base*.
- **Characterization and appropriation:** It includes projects related to the characterization and appropriation of components, tools, kits, or other equipment.

- *Performance Study of Wheels and Motors of the Vex Robotics Platform***.** (*See Figure 7).*

Figure 7. Robotics platform

- *Measurement and visualization of the charge level of the battery and other competing sensors*.
- *Prediction of useful life of lithium batteries***.**

Some of these projects in Expoelectronics Fair and others events, are shown in the next figure.

LEARNED LESSONS

During the development of the class, different experiences have been had, which have served as a point of reference and learning, to improve the methodology used. Some of these learned lessons are the following:

- **Working with classmates of different semesters:** having work teams composed by students from different academic semesters was well accepted, especially by younger students, who were able to acquire concepts of their career in early stages (e.g., specifications of the electronic components) and relate to classmates from higher semesters.
- **Interdisciplinary student teams:** this course offers engineering electronics students the opportunity to work together with students from other programs such as industrial design and systems engineering.
- **Participation of professors and graduate students:** it also allows interested professors and graduated students to carry out projects with students.
- **Communication skills:** the elective course provide students with spaces to promote communication skills, such as writing, and speaking. In the reports generated by students, it was found that they lacked adequate writing skills, especially in freshmen students. Students received feedback on their writings and oral presentations. Additionally, they were given tips to make better presentations and reports.
- **Project management:** during the development of projects, students have to learn to manage time, manage a budget, and make national and international purchases of components and hardware.
- **Creativity and problem solving:** this course promotes the design of projects that solve problems or needs of the student or the community.
- **Student interest:** the development of the project of interest of the students increases their motivation to finish it successfully. In this process, students learn new concepts and develop skills.

CONCLUSIONS

Although the course was initially designed for students linked to research groups, students not linked to these groups have also been interested in carrying out projects.

Offering the opportunity for students to develop projects of their own interest and not mandatory, helps them remember why they entered engineering and increases their motivation.

Special Projects on Electronic Engineering class uses the motivation that students have for the development of projects of their interest, as the central motor of their learning.

The oral and written expression of the students improves considerably when they must do it continuously, every week, as part of their project, which gives them an additional motivation.

When asking or correcting their classmates does not affect the grade, but rather collaborates with the development of the project, the students do it more often and receive it better.
Although it is a class designed for electronic engineering students, students from other programs such as systems engineering or industrial design have enrolled, which has produced very good results of joint work.

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