

INNOVATING IN TEACHING AND LEARNING AT FIRST YEAR OF ENGINEERING

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ABSTRACT

This paper shows how a team of highly motivated teachers at the University of Santiago, has started an innovation program in teaching and learning at electrical engineering career, having as a reference the CDIO framework. The design considered two courses: a general course of Introduction to Engineering at first semester and a course of Introduction to Electrical Engineering at second semester of the first year. Designers teachers aim to stimulate students' interest in their careers, strengthen their motivation and develop skills and attitudes to provide a wide vision of engineering that ties the technical scope of the profession with a social and environmental dimension that transforms ethics and social responsibility into important subjects. Students, working in teams, had to investigate about topics of the courses, write a report and make an oral presentation to the class every week. At the second course, they also had to face a simple project of engineering: to control the movement of a mobile robot with a microcontroller on board. This design-implement-operate activity was very stimulating for students. This positive experience of active learning, obtained at first year, is the initial step of a program of innovation in teaching and learning in our Faculty.

KEYWORDS

CDIO, teaching and learning, introduction to engineering.

INTRODUCTION

Innovation in teaching and learning has happened in the Faculty of Engineering of the University of Santiago, due mainly to individual efforts of some teachers. Collective work has been done to design new curriculum, which occurs every ten years approximately. However, these changes have not modified the way of teaching and learning. Many courses are still based on traditional lectures and evaluation of the capacity of students in solving exercises.

In 2011, Faculty of Engineering invited a group of teachers of different engineering disciplines in order to study and propose changes in the process of teaching and learning. During that year, the group discussed, analyzed the situation up to that moment and decided to begin changes with a common course of Introduction to Engineering using active learning, and taking the CDIO initiative as a reference [1]. The idea was to obtain experience and then, to promote changes in other courses gradually. The Faculty is formed by nine Departments: Mechanical, Electrical, Chemical, Mining, Metallurgical, Industrial, Civil, Computer Science and Geographical Engineering. Students enter to the university, being registered in one of the nine careers corresponding to the academic departments, they choose.

The group of fourteen teachers, working two hours a week, designed a general course of Introduction to Engineering and the corresponding didactic material. The experience of this multidisciplinary team was very rich. The same group of designers teachers were in charge of the course. During the second semester of 2011 and at the first semester of 2012, another group, this time formed by seven electrical engineering teachers, working also two hours a week, designed the next course: Introduction to Electrical Engineering. Some of them had participated in the first group, therefore, the methodology was the same.

At first semester of 2012, a total of 1,915 students, belonging to the nine engineering careers were registered in the common course of Introduction to Engineering, being 267 electrical engineering freshmen. The course was divided into 32 classes of 60 to 70 students each one. Each class was randomly integrated by students of different engineering careers.

METHODOLOGY

The first day was the unique typical lecture where just the teacher made a presentation to show the objectives of the course, the thematic units, the methodology and the assessment system. Next presentations were done by students. All classes were organized in groups of 5 to 7 students. They had to investigate, working in team, about the topics of each course thematic unit. Students had to prepare a written report of 5 pages and to make an oral presentation of 10 minutes to the class every week.

At the beginning of the lecture, teachers selected 2 teams and one student per team to make the presentation. This required that all teams and students had to be prepared. After students presentations have finished, teachers summarize the principal points on the topics, ask some

questions and present the topics to be studied for the next class. In spite of the great change this way of working meant to students, who had only traditional lectures at high school, they reacted positively. There was no initial resistance to cover material on their own as has happened in some engineering schools [2]. The rules and the way of working was clearly established since the first day and published through the virtual platform of the university. All teams prepared all reports and presentations. The first reports showed a lot of orthography errors, deficient editing and lack of format. Assessment of each of the reports considered these aspects affecting the evaluation the teams obtained. Thus, reports were improving every week and at the end of the semester, the results were acceptable. Students made good oral presentations in power point, since the beginning.

COURSE OF INTRODUCTION TO ENGINEERING

The objectives of this course are:

- Strengthen motivation of students to study engineering through the knowledge of what engineers do: conceive, design, implement and operate products and systems [1], taking into account the importance of social, environmental and ethics aspects.
- Introduce students in the concepts of modeling and engineering projects.
- Increase the development level of the following skills: team work, self-learning and written and oral communication.

The course was organized around three Units: Origin and evolution of Engineering; The role of engineers; and Tools used by engineers for solving problems.

In first Unit, students had to investigate about the most important milestones in engineering, in general. Then, they continued studying about Engineering, Society and Environment; and Science, Technology and Engineering. In second Unit, students investigated about the role of engineers, where they work and about the profile of engineers of the University of Santiago. Finally, in third Unit, students investigated about design, models and engineering projects. They spent 80 hours on this course.

COURSE OF INTRODUCTION TO ELECTRICAL ENGINEERING

The objectives of this course are:

- Strengthen motivation of students to study electrical engineering.
- Introduce students to main basic concepts and principles of electrical engineering.
- Continue improving the development level of the following skills: team work, self-learning and written and oral communication.
- Allow students to face an electrical engineering project.

The course was organized around four Units: Origins and evolution of Electrical Engineering;

Basic Concepts; Models in Electrical Engineering; and Microcomputers and the Project. In first Unit, students had to investigate about the most important milestones in the development of electrical engineering; the main areas of specialization and the application of electrical engineering in the real world; and finally, to discover where electrical engineers work. In second Unit, students had to investigate about some basic concepts of electrical engineering selected by the teacher and about some of the basic principles of electric circuits and signals. In third Unit, students investigated about the models used in electrical engineering. Finally, in fourth Unit, students had to investigate about the structure of microcomputers and microcontrollers and their principle of operation. They also studied how to design basic algorithms, flow diagrams and the principal instructions of Basic language. They also spent 80 hours on this course.

ASSESSMENT

Assessment of the course of Introduction to Engineering was done through the weekly reports of units topics and oral presentations. Students elaborated an electronic magazine with a resume of all presentations and a video about the Faculty of Engineering. Final scores were obtained as an average of the marks obtained in reports and oral presentations. Additionally, students had to assess themselves and to their team mates through a rubric. This considered the fulfill of the tasks assigned by the group, at due time; active participation in team meetings; and a constructive attitude and respect to the opinion of others. Rubric allowed the teacher to distinguished individual performance of each member of each team. Students expressed through a survey to be satisfied with this first contact with a course that showed them what is engineering, where engineers work and what they do. Two engineers, working in cooper mining enterprises, were invited to the classroom to talk about their jobs. This was a very motivating activity.

Assessment of the course of Introduction to Electrical Engineering considered three instances:

- a) Reports and oral presentations
- b) Project
- c) Written test.

Final score was calculated as an average of them.

It was detected, at the beginning of the course of Introduction to Engineering, that one team just copied the written report from internet. This report was assessed with the minimum score (1,0) and the situation was communicated to all students. This fact served to highlight, through some examples, ethics problems that engineers had to face and the responsibility they need to show.

THE PROJECT

Students can learn experientially about system building through team-based design-build-operate projects and develop a deep working knowledge of the fundamentals [3].

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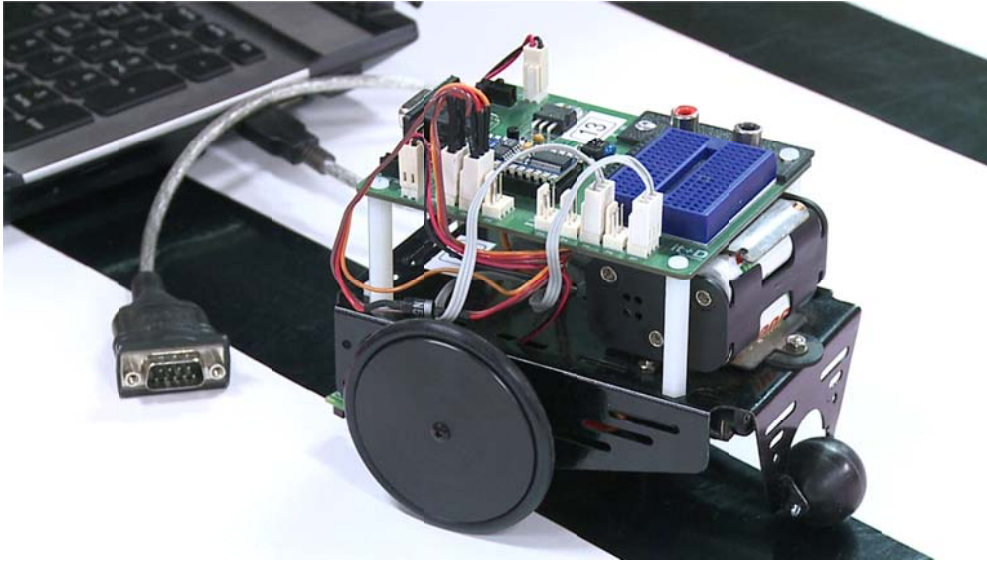


Figure 1. Mobile robot used by students

The challenge presented to students in the course of Introduction to Electrical Engineering was to control the movement of a mobile robot through a black lane painted on a wood base. Figure 1 shows one of the 30 robots available for students practice. At the end of the lane, the robot has to stop, rotate in 180 degrees and go back to the starting point. Each mobile robot has a microcontroller on board (Basic Stamp 2sx from Parallax.Inc) which may control the servomotors of each of the two big side wheels. The small central wheel is free running. Students had to investigate about the microcontrollers structure, its principle of operation, servomotors and infrared sensors. To solve this problem, students, working in team, had to conceive the solution, design the program in Basic language, load it into the memory of the microcontroller and run it. After the program was debugged, all teams participated in a competition. Figure 2 shows a group of students during the competition. Winner team obtained one point increment in his assessment. Project took just the last 4 weeks and all teams had good results. This project generated high motivation for students who enjoyed this activity. Even when most of the teachers of the Department considered a very good experience at first year, some of them were concerned about some limitations, identified clearly at MIT [4], particularly, the excessive time that some students could spend in the project.

RESULTS

Introduction to Engineering. As mentioned before, at the first semester of 2012, a total of 1,915 students attended to this course. They were registered in one of the nine engineering careers of the Faculty. A 4 % of them, failed, they got a final average score under 4,0. Most of them also failed in Algebra I and Calculus I, and therefore, they abandoned the course before the semester finished. In this course, there were 267 electrical engineering students. Coincidentally, a 4% of them also failed.



Figure 2. Competition of mobile robots

Introduction to Electrical Engineering. At the second semester of 2012, a total of 238 electrical engineering students were registered in this course. They were organized in 7 courses of 30 to 35 students each one. In this course a 6 % of the students failed. At the end of the semester students were asked to assess some aspects of the teaching and learning process, using a rank from 1 to 7, being 7 excellent and 1 deficient. 164 students responded indicating that their motivation to study electrical engineering had increased (average mark 6.2). Respect of their understanding of the importance of social, ethic and professional responsibility of engineers, they evaluated 6.0. In relation with the capacity of instruments used to evaluate the work done by students, they marked 5.5. In general, in the open comments section, students indicated they felt satisfied with both courses and suggested to include more exercises in next courses.

An important factor in the design and development of these courses was the experience and motivation of the groups of teachers that implemented them. The design of each of these courses took 9 to 10 months, similar time to that spent by similar school of engineering [5].

Teachers analyzed the global teaching and learning process of both courses and considered that the following CDIO skills have been covered in a first level: problem identification and formulation (Syllabus number 2.1.1), solution and recommendation (2.1.5), experimental inquiry (2.2.3), perseverance and flexibility (2.4.2), curiosity and lifelong learning (2.4.6), professional ethics, integrity (2.5.1), team operation (3.1.2), written communication (3.2.3), electronic/multimedia communication (3.2.4), oral presentation and inter-personal communication (3.2.6), roles and responsibility of engineers (4.1.1), the impact of engineering on society (4.1.2), the historical and cultural context (4.1.4), developing a global perspective (4.1.6), the design process (4.4.1) and software implementing process (4.5.3).

CONCLUSION

The courses of Introduction to Engineering and Introduction to Electrical Engineering were designed by the same groups of teachers working in team that, later on, were in charge of them. This fact allowed to share different visions and agreed the application of an active learning style. Students responded satisfactorily to this method. All of them, worked in team, prepared their reports, made their oral presentations and finished the project according to the initial plan. The quality of reports was improving every week in orthography, format and editing. Students learnt that these aspects are important and that they are evaluated. The level of oral presentations was well for a first year course and also showed progress. Randomly choosing of teams and one student per team, just at the moment of oral presentation, forced them to do team work. The reference to the responsibility and ethics was present in many lectures. However, it was detected that many students do not see clearly the ethics problem of plagiarism.

The project was, without doubt, the most attractive activity for students increasing their motivation for electrical engineering. Experience obtained through these two courses has been shown to others teachers of the Electrical Engineering Department giving emphasis on the benefits of these changes.

FUTURE WORK

Teachers involved in these courses will apply the active learning and based problem learning methods in their other courses, in 2013. The authorities of the Electrical Engineering Department will stimulate the teachers to be in charge of these first year courses, at least, one semester. On the other hand, a curriculum group, recently created, will prepare an innovation program to foster teaching and learning in our careers, based on CDIO Initiative.

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