Projects Proposals to Improve Engineering Learning

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Abstract: In this paper we present some of the projects developed in last two years at the ITESM Santa Fe, the results and observations that this experience produces. We will note that project oriented learning (POL) is one of the best strategies when teaching basic and advanced engineering subjects because principally students are able to link all theoretical framework that basic courses provides (biology, mathematics, physics, etc.) to real world applications. We also note that some skills are reinforced and other are developed in students during the project realization, providing better engineering education.

Index Terms: POL, Engineering Education, Pedagogy.

I. INTRODUCTION.

It is very common to incorporate project-oriented approaches when teaching engineering subjects [1]. This learning strategy allows students to seek information by their own while developing a well defined project, also contributing to the development of the collaborative work ability. We note the constructionist educational philosophy of Papert [2] establishes that the construction of new knowledge becomes more effective when learners are engaged in constructing products that are of interest to them or are useful in some other sense. From an educational point of view, the theory of Papert can be linked to the constructivist theory of Jean Piaget [3]. According to this theory, learning comes from an active process of knowledge construction. This knowledge can be gained through real life experiences and linked to a learners' previous knowledge. In consequence, we can say that project-oriented approaches are ideal for teaching some topics in engineering.

All these observations guide us to propose periodically in some of the courses given in the Engineering Division at the *Instituto Tecnológico de Estudios Superiores de Monterrey* (ITESM) Campus Santa Fe a set of well defined engineering projects, oriented to provide social, educational, industrial or basic research solutions. From this set of projects, students are able to select the one that best fits to their interests and motivations. This fact is very important, because a student without interest in developing a (imposed) project usually fails or the final results can be catastrophic.

Students, at the end of the project, have to deliver a prototype (hardware or software) with documentation, exhibit the project in a poster session and present the prototype in front of a jury, which is in charge of its evaluation. It is important to mention that students not always are candidates to graduate but they are students at the beginning or middle of their career, and then this experience can be new, exciting or even stressing. We consider that these activities guide students toward professionalism.

In this paper we present some of the projects developed in the last two years at the ITESM Santa Fe, the results and observations that the experience produces. We will note that project oriented learning is one of the best strategies for teaching advanced and basic engineering subjects, because, principally, students are able to link all theoretical framework to real world applications.

II. ENGINEERING EDUCATION

In Mexico, it is becoming difficult to recruit students to study engineering, no matter that in the labour market the engineers are much demanded and they will become fundamental pieces in their works, besides,

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students do not have clear that engineers are indispensable for prosperity of a society. Moreover, talk about engineering students that become researchers is a utopia.

However, universities have to ensure that graduates will be ready and able to face and overcome increasingly complex roles in a rapidly changing technological environment. The ideal characteristics of engineers are a good grasp of engineering science fundamentals, a good understanding of design and manufacturing, good communication skills, curiosity and desire to learn for life [4].

Another point of view concerning to the desired characteristics in an engineer is found in [5], where they consider that the generic skills and attributes to have are:

- Technical knowledge and skills: practical ability e.g. use of modern technology.
- Intellectual skills: ability to learn and understand new information.
- Attitudes: behavior, thoughts and actions.
- Standard of engineering practice: awareness and observance of engineering codes of practice and ethics; understanding of the role of an engineer; and general knowledge of the working legislation and regulations.

In literature we can find many possibilities concerning the engineer characteristics [6]. However, we would like to mention or add one more skill: an acceptable social behavior in their work places and the ability to explain their activities to their workmates. In other words, it is desirable they be "open" to everyone (these latest characteristics were determined from a study carried out in a market research to determine the possibility to open a new Engineering Master program at ITESM Santa Fe).

On the other hand, industry and universities not always expect the same form graduates [7]: Universities gives preference to theoretical knowledge in the professional field; industry desires that engineers have excellent communication skills, interest in new skills learning and teamwork. Such observations are true, however, concerning what universities want at ITESM Santa Fe we have an important statement to accomplish named "La Misión 2015".

"La Misión 2015" establishes that it is mission of ITESM to form integral and ethical persons, with a humanistic vision and internationally competitive in their professional field, being at the same time citizens in commitment with the economical, political, social and cultural development of their community and the sustainable profit of natural resources.

In simple words, the duty of universities, and particularly at ITESM, is to "produce" engineers with a strong formation that allows them to perfectly fit in any organization and society as a gear in a perfect clock.

At this point, some questions arise: What should be engineering education in universities? What type of engineers has to be produced by the universities? What are the engineering duties?

We have many responses, but in this point we only matter one: We must provide the best education and formation possible, according our resources, ideas and beliefs; according to us.

III. PROJECT ORIENTED LEARNING (POL).

Project oriented learning is a method where groups of students are actively engaged in trying to solve or address real-life professional problems and situations [8]. The benefit of such an approach is that they learn how to interact with one another and the community around them; they learn skills, gain knowledge, develop attitudes and behaviors which will allow facing and dealing with responsibilities, problems, or difficulties better in a work scenario after finishing their studies [9]. The objective of POL is mastering the following skills in students:

- Teamwork
- Communication skills
- Writing skills
- Problem solving and planning
- Taking risks
- Professional behaviour
- Project management skills
- Time management

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- Delegation of tasks
- Accessing and acquiring information
- Applying knowledge
- Acquiring new knowledge
- Disseminate knowledge

We design some courses under this learning approach, and propose several projects to develop according the topics and objectives we pursuit.

IV. PROJECT PROPOSALS.

We note that engineering education could be an extraordinary challenge. Modeling students as mud to become the vase that industry and university want is not easy. However, we consider that some educational strategies can be very useful. As menioned above, we consider that POL is a very effective strategy. The principal reason is that POL allows to link theory with practice, which is very attractive to students.

We consider that an important fact to have success with POL is the project definition. If we propose well designed projects, where objectives and methodology are clear and precise, and the project motivation arise naturally from students, the learning process will be satisfactory and the project will be successfully concluded.

Basically, the proposed projects should follow or contain the next actions:

1. Definition of objectives and motivation.
2. Study of state of art.
3. Search of possible solutions.
4. Selection of best solution.
5. Implementation
6. Results
7. Conclusions and future work
8. Bibliography and references

As can be noted, students must follow the methodology employed in most research projects, but some times a market research and manuals are required, especially when the project consists in the construction of a final product of excellent quality. Next we present some of the projects proposed to engineering students in different classes, which have been successfully concluded.

A. Home Monitoring and Control by GSM

The objective of this project was to develop a system to control some electrical devices at home by GSM messages (cell phones). In this work, the students decided to control the home irrigation system (Fig. 1). In brief, the idea is to send a GSM message to home to watering plants when one is traveling or in vacations.

A GSM modem receives the message, decodes and interprets it, activates and deactivates the irrigation system and sends a message back when the task is concluded. One possible problem is latency, but in this kind of activities, it is not relevant.

The realization of this project implied that students had to study some GSM principles, design and construct an electronic interface and program the GSM modem. The results were satisfactory, and actually, a small enterprise was created by the students taking advantage of the project results and the acquired knowledge.

In this case, the motivation was very important to be successful. The established plan was carried out correctly and all necessary tests and corrections were performed.

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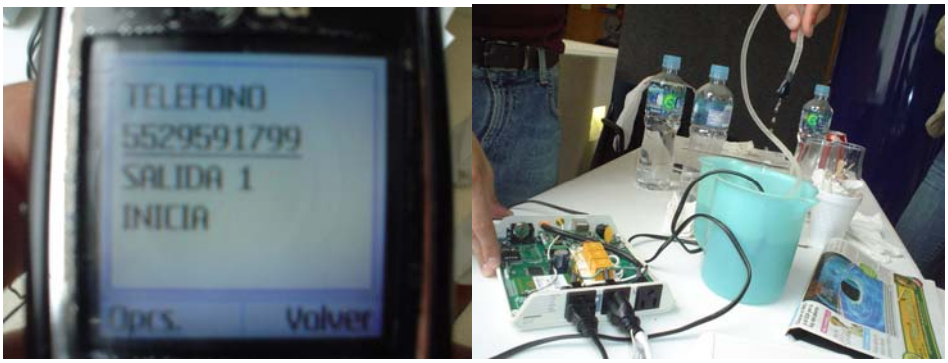

Fig. 1. Testing the GSM project.

B. Hydraulic Manipulator Design

The objective was to construct a manipulator (robotic arm) moved by hydraulic-motors, similar to the ones employed in industry but in a minor scale. The manipulator was designed to have four degrees of freedom type RRRR (Rotational, Rotational, Rotational, Rotational). All mathematical considerations were carried out. The robot structure was carefully designed and the aluminum parts were manufactured in the laboratories of the campus (Fig. 2) using a CNC (Computer Numerical Control). Before beginning the manipulator design and construction, students made some research about the state of the art of manipulators. The use of hydraulic motors in small robotic arms is not very common; stepped, AC and DC motors are most commonly employed. In consequence, students realized that the state of the art research was fundamental. In this project, some training was necessary, especially for the CNC employment.

Once the hydraulic manipulator was finished and tests began, the students were excited because they understand the relationship between all mathematical calculus they carried out and the performance of the arm: a harmony game.

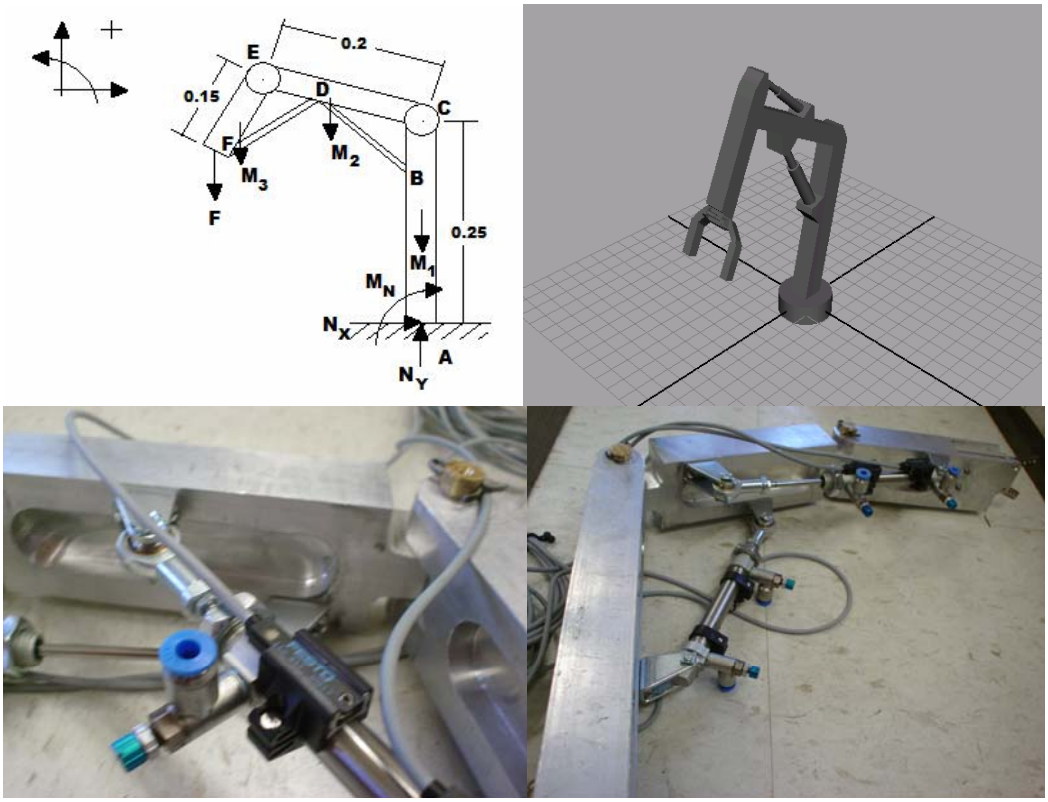

Fig. 2. The hydraulic manipulator.

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C. Crabot – the Cleaning Robot.

The project was designed to help students in learning Java programming and the subsumption robot control architecture. It essentially deals with the design and construction of an educational indoor cleaner robot named Crabot (Fig. 3). Crabot is a LEGO based autonomous mobile robot, which represents the prototype of a real robot for house cleaning which requires a minimum of intelligence. Crabot is provided with necessary items for floor cleaning such as a small vacuum cleaner and a brush. The control system is based on the subsumption architecture with memory, and offers a repertoire of behaviors for navigation and cleaning. This kind of control system allows mixing real-time distributed control with behaviors triggered by robot sensors. Crabot was tested in an artificial world and in competition where its performance was very acceptable.

The importance of this project, more than the challenge and excitation produced in students, is that it helped to introduce them to advanced topics of robotic control: they learned the subsumption architecture. Fig. 3 presents two versions of Crabot.

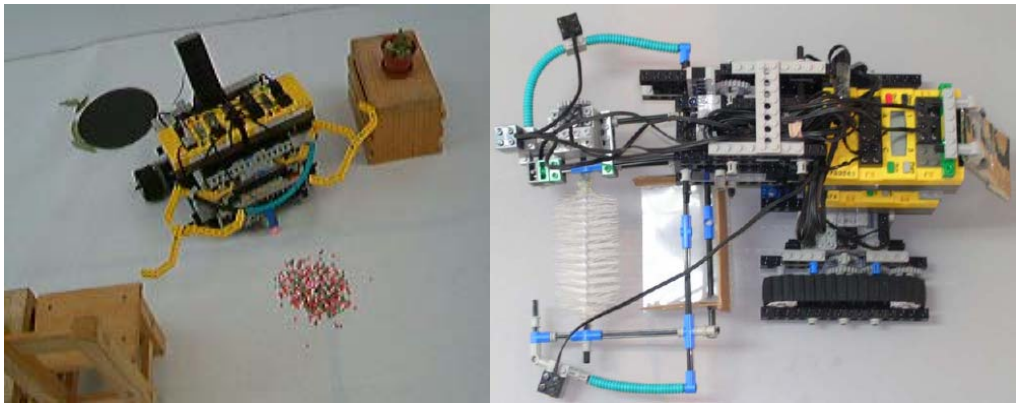

Fig. 3. Crabot- the cleaning robot.

D. Robot Teleoperation by the Web

The project consists of developing a user interface (a web page) to teleoperate a mobile robot where a web server is configured. The idea is that user controls the robot by pushing buttons or dictating commands (voice) through the interface. The robot (a Pioneer model) has a camera, and then the captured images are sent to the interface and presented to the user. The user voice is sent to the web server where it is processed and translated in commands to be executed by the robot. Additional considerations are included in the robotic system control, such as the task of avoiding obstacles.

At first, the students needed to understand what intelligent agent and multi-agent systems are to develop the project. Next, network protocols and speech processing were employed, and then these concepts were also learned.

In particular, this project is beautifully complete. It involves, advanced programming concepts and abilities, robotic control, network protocols and voice recognition knowledge. A real challenge for any student.

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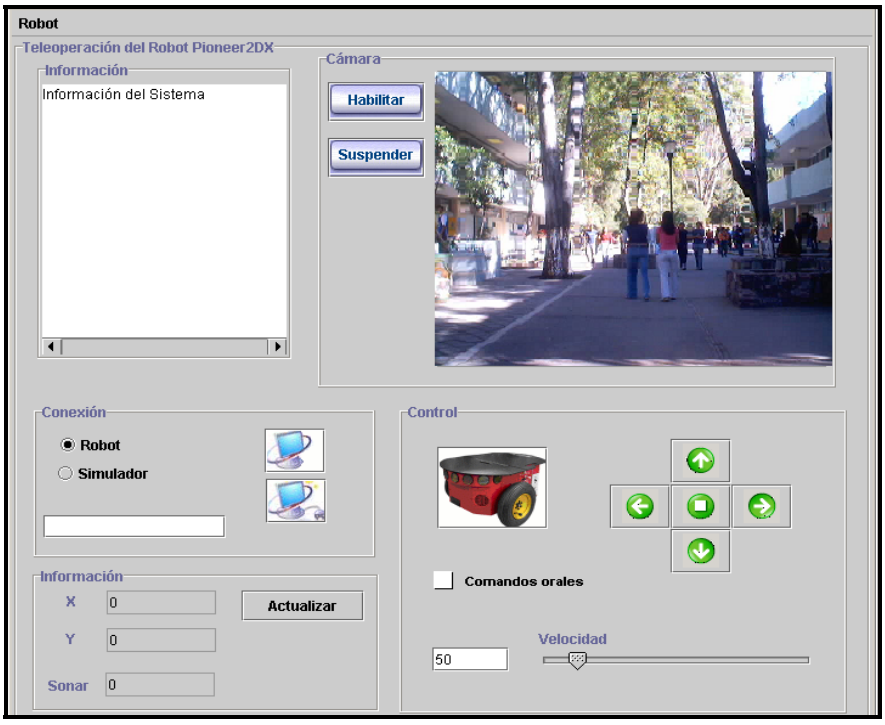

Fig. 4. User interface to teleoperate a Pioneer robot.

E. JURODI

This is the last project we present in this paper. The principal objective was the development of a series of educative robots, which will be employed by kids between 5 and 14 years old. One characteristic of these robots is the low price, less than $20 US. We pretend to make them accessible to almost any one. The robots are a kind of puzzle, which can be easily and intuitively assembled by kids. We also pretend to introduce to kids concepts related to robotics in a basic and simple fashion. It will be their first contact to mechanics, electricity and electric circuits' ideas. It could sound bizarre, but a psychological study was performed to determine the robot characteristics.

Fig. 5 presents the first model, intended for 5 to 7 years old kids. This model was presented to many kids who were fascinated with the "toy" and the response was fabulous. This robot will be commercialized and the price will be around $10.00 US if it is massively produced.

On the other hand, engineering students, participating in this project learn a strategy of work very unusual, especially when they had to carry out the psychological research on kinds.

Fig. 5. JURODI.

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V. CONCLUSIONS.

The projects proposed in different courses really help students to have a better formation. They help to improve some skills, behavior and attitudes on them, such as the ones mentioned above.

Writing correctly the project report, and present the project in front of a jury are the activities where they find most difficulties. However, they improve a lot their writing because along the course of the project, several reviews are carried out. Some times short courses of technical writing are given.

The poster session usually is a previous activity where they receive a feedback from different professors. After this activity they can improve their project, and the ability to talk in front of people. Usually, when students present their project, they get nervous. In consequence they have to learn to manage the stress.

It has been surprising that some projects go on, becoming commercial items, or providing more abilities to students.

We also have noted that the response to introduce POL in classes is well accepted, even if they have to work more than in courses without POL. The challenge is exciting.

We can conclude that POL produces good results, especially if we are trying to accomplish "la Misión 2015" and find the harmony between the universities and industries demands concerning the engineering students' skills and abilities.

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