Taller Encararé

Creativity and Entrepreneurship in Engineering

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Abstract
A curricular subject of Electrical Engineering, called Taller Encararé, is described. In this experience, students working in groups are encouraged to diagnose problems within a specific area of the society, creating sustainable solutions and planning its implementation. At the end of the semester, students present a business plan where the definition of the problem is a business opportunity and the solution is an entrepreneurship with the technical, commercial and financial challenges identified and accounted for.

Key words:
Creativity, Entrepreneurship, Projects, Business Plan

I Introduction

Taller Encararé ¹is an innovative experience of active learning education in the Electrical Engineering career. Its main objectives are: work in interdisciplinary teams, learn project methodology by using it, develop creativity and entrepreneurship, raise students' awareness about important problems of our society and the possibility of making a positive impact through engineering.

¹“Taller” is the spanish word for “Workshop”. “Encararé” is the future form of the verb “Encarar”: “To face up”.
Taller Encararé was born in 2007 as a curricular subject of four months of duration (one academic semester), and it was based on previous students' workshops and similar experiences at other universities. Students are from third and fourth year of Electrical Engineering (a five-year career), with a considerable background on Physics and Mathematics, basic formation on basics of Electrical Engineering (digital circuits and linear systems) and fundamentals of economy. Also, since 2009 advanced students from the Industrial Design school are invited to participate and they work together with Engineering students.

II Organization

Students are arranged in teams of four or five at the beginning of the semester, and each of these teams has to work in a specific area, such as agriculture, health, disabled people, education, etc. Each team is assigned a professor as a mentor that helps for discussing, analyzing and making decisions.

Through interviews with people working in the area, they diagnose problems or discover business opportunities, that can be solved with engineering. Students have to recognize actors, define success criteria, and identify constraints and assumptions around each problem. This is a key step of the process, because all the following stages are based on an accurate definition of the problem. Additionally, it is the most complex stage, given that it implies “logistic” factors (such as arranging interviews and visits) and communication with social actors, that not necessarily have an university education.

Problems are discussed within the group and presented to each other. Using the KJ technique (named by its inventor, Kawakita Jiro; sometimes is called Affinity Diagram), students analyze the problems, in order to have a full understanding. Each student writes in pieces of paper phrases related with the problem, and then throws them in a common basket. All the pieces of paper are anonymous, so the ideas are not owned by one participant, but are property of the group. The pieces of paper are taken off the basket and arranged by similarity. At the end, there are several sets of ideas, that helps to understand all the components of the problem studied.

The next step is the design of possible solutions to the problems, using techniques like brainstorming or round robin. At the beginning of this stage, all ideas are welcome, without analyzing their viability or sense, because only matters the amount not the quality. Also, existing solutions are studied reading patents in international databases, browsing products in the Internet and analyzing other solutions used by people.

After discussing possible creative solutions, each group chooses one for improving its
design. The first level of design was block diagrams, so the following step is the design of each block. Students have to make technological decisions (such as chips models, communication protocols, software languages, etc), helped by specialists in the areas involved. When presenting the solution, a key aspect is the creation of storyboards about how it would be used, in order to assign a high relevance to the view of the possible customers.

Then, students plan the implementation of the prototype, by doing an engineering project plan. Costs, time, human resources, risks, tasks needed are studied and arranged. Standard tools as Work Breakdown Structure, Critical Path Method and Gantt chart are used in this stage.

Finally, each team has to write a business plan, describing the product, analyzing the market and competitors, defining the structure of the company, financial plan, marketing strategy, etc. At the end of Taller Encararé, students are ready to apply for financial support for the implementation of the engineering prototypes designed by them. Students are advised on possible grants or seed funds to apply for, but the course of action to take -whether to apply or not, and where- is decided by them.

In parallel with these activities, students are presented with lectures on topics like team work, product design processes, business plans, and project management, as well as invited talks given by entrepreneurs. The latter have been evaluated as very positive by the students because they can visualize entrepreneurship as a real alternative for their future professional career.

III   Key features

Students learn project methodology in an active form, using them for their own prototype. The main innovation of Taller Encararé is that the problems solved by students are identified directly by them, exchanging with social actors. Each team has to discover a new reality in few weeks and find problems, needs and opportunities there. Autonomously, students recognize actors, success criteria, constraints, and assumptions around a problem to solve. Usually, problems are hidden under their symptoms, so they are not evident and not easily identified. A common failure in engineering projects is correct problem diagnose and specification. In Taller Encararé, students are presented with lectures about finding problems and opportunities, but the real learning process is made by themselves, in direct contact with social actors.
One crucial aspect of Taller Encarnaré is its integralty on the three main university's functions: education, research and extension (direct work of universitary actors in the community, with horizontal and bidirectional communication, in order to achieve social change). Students learn theoretical aspects in class, create new products and exchange continuously with social actors along the duration of the subject. Integrality allows a better learning process, because it is not considered linear, but a complex process with many actors, with changing roles. In some points of Taller Encarnaré, students are in traditional classrooms, whereas in other they have to innovate by creating products useful for society. At the very beginning, they learn a lot about a specific context from social actors, and then they teach about this complex reality to other students and professors. There are plenary sessions at the four milestones of each project: problem identification, design of a solution, project plan and business plan. In these plenary sessions students of each group present and discuss their work with the other students and the professors, that contribute from points of view not considered by the team, improving its work. Additionally, students learn about making effective oral presentations in an active form, improving their communication skills.

IV Case study

Since the first edition of Taller Encarnaré, groups of students work in the area “ICT in Education”, that in Uruguay implies Ceibal Plan, the Uruguayan implementation of the One Laptop per Child program. All the students of primary public schools of Uruguay (more than 350.000) have an XO laptop. The laptop is owned by the children, who use it at home too, providing access to Internet to thousands of families. So, the XO has changed lot of things in Uruguay, from the education to the everyday life of many people.

In 2008, a group of students of Taller Encarnaré visited several public schools that have implemented Ceibal Plan. They exchanged ideas with teachers and children in the classroom. The first problem was explaining what is Electrical Engineering to Primary School students from poor families. For the teachers, an Electrical Engineer repairs and programs computers. So, when asking for problems, the answer of teachers was “we need specific programs, for teaching mathematics, physics”, while children wanted more games for their XO. The students also interviewed engineers and technicians that worked in Ceibal. Although there is a better understanding between Engineering students and technicians, the problems discussed with them were worst defined that those from schools. The reason is that, normally, a technician or engineer has not the mental concept of a problem, but the problem with “the solution”, that normally is suitable but not optimal, because the exact problem is not well defined (some actors can be ignored, some constraints can remain unseen, for example).
As it was described in the previous Section, there are visible problems that sometimes are not the most important ones (assuming that the relative importance of a problems is related with the impact of implementing a solution). Diagnosing implicit problems is a very difficult task, and though some cases are discussed in the classroom, the challenge is to do it in the reality. In this case, students were able to identify a problem (that was an opportunity too), related to the usability of the laptop by the children. The mousepad of the XO was very difficult to use, specially for drawing, that is a very common activity of expression for children. The students concluded that improving this would change the relationship between the children and the technological tool, making it more friendly.

As a result, they designed Lapix, a versatile product that allows new uses of the XO laptop (the name is inspired by the spanish word for pencil: “lápis”). The main component of Lapix was like a pencil that worked over the XO screen, but without installing a touchscreen. It can be used as a mouse pointer, because it had three buttons: one as the primary at the tip, the secondary at one side, and an on-off power button at the top. Also, it can be used for drawing and writing, that it was very important for children but for primary teachers too, because they were afraid of skills of handwriting could be lost by the intensive use of computers by the students.

The whole system of Lapix was composed by the wireless pencil, whose position could be determined by triangulation with a RF receptor located on the top of the computer. This receptor was connected to the laptop by an USB port, as a common mouse, containing most of the electronics: a 20 MHz microprocessor, AD and DA converters, flash and RAM memories, RF antenna, etc. In the pencil, there were essentially a battery, a DAC and a Pierce oscillator. All the processing was made by the device itself, and no software install was needed for using Lapix. This was a key feature of the product, because children had not root privileges in their computers, making impossible the installation of drivers. They defined specific components for each part of the system, in order to be compatible between them (for example, same levels of operating voltages), and for simplifying manufacturing process (all SMD). Ergonomic and aesthetic aspects of the solution were also considered in the mechanical design.
Additionally, an open-source activity called Cuadernox was developed. This activity allows the use of the XO as a traditional notebook, with a simple interface where children could write and draw freely, moving between pages.
Students made the planning of the project for implementing a prototype, defining accurately the main and specific objectives, and tasks through WBS (Work Breakdown Structure). Time management was planned with a Gantt chart, using the critical path method. They studied eventual risks and designed contingency strategies. Costs were analyzed, resulting in a low development cost (2,500 USD) and a very low cost for series manufacturing (around 25 USD). Finally, they wrote a business plan, where they studied the market, designed a distribution and marketing strategy, and sketched the structure of the startup company.

After graduating from Taller Encararé, Lapix was taken as the subject of a capstone project with the objective of building an engineering prototype, funded by Ceibal Plan. Even though some technical details changed (for example, RF communication was changed for IR), the most important features of the prototype implemented were taken from the solution designed in Taller Encararé. The implementation of this project, based on the funding from an external entity like Ceibal, is a social validation of the implicit needs diagnosed by the students. At the present, the capstone project has finished successfully with a working prototype and the students are evaluating the possibility of starting the development of a commercial version of the product.

V Conclusions

Taller Encararé is an innovative experience, where students learn several techniques of entrepreneurship in an active form. Working in groups, they undertake the challenge of meeting a particular area of society (such as agriculture, health, disabled people, etc) for finding problems and designing and solutions for them, exchanging continuously with social actors involved. By doing this, they develop skills that are not usually covered in the standard curricula.

Students create solutions that are technically and socially feasible, and in some cases (like Lapix) are implemented after Taller Encararé with funding coming from the social actors involved. This demonstrates that active learning is a suitable educational methodology for teaching complex skills, like communication, creativity, teamwork and entrepreneurship.

Although students and professors from industrial design have participated in the experience, it is pretended to include in future editions other engineering areas (such as software, mechanical and industrial), economy and sociology, in order to improve the projects through interdisciplinary teams.