# Entrepreneurship Training: a case study in Engineering Students


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***Abstract*** — *The paper describes the results of an educational project aiming to promote improved learning and entrepreneurial spirit among engineering students by resorting to the simulation of real world business cases in a collaborative digital environment. The fundamental motivations are the following: (a) Due to the emphasis that is made in the basic preparation and the specific technologies of each engineering field, frequently, engineering students tend to ignore the non-technological aspects of their profession, such as market awareness and communication skills. As a result, when starting a career, many of these students have a very limited knowledge about the businesses where they become involved and show important weaknesses when they need to plan, organize and present their work. These problems are further aggravated when they have to do all this within a team. Such limitations can significantly impair their capability of playing the roles that enterprises expect from them and may, thus, jeopardize their employability. In addition, these weaknesses also do not favor the emergence of an entrepreneurship spirit, restricting their career opportunities and their ability to contribute to economical and social growth. (b) A large amount of students find that classes are boring. This is mainly due to two different causes: first, because of their limited real world experience, they have difficulty in understanding the practical applications of their studies, and second, as a direct consequence of the traditional universities' teaching approach: they receive tools for solving problems that they have never faced before. The project described by this paper tackles the above problems by implementing project-based active learning combined with an interactive entrepreneurial atmosphere in the area of telecommunications engineering. The approach also involves the collaboration of a selected group of invited industry professionals that participate, helping students to create real world business cases, with different teams playing the roles of competing companies in a marketplace. The critical tools for success in this game are team work, the dynamic features of a collaborative digital environment and a sound command of networking fundamentals: enabling technologies and services, business models, market structure, relevant players, consumer trends, environmental constraints, etc. The results obtained so far are encouraging and have attracted a major international prize: HP Innovations on Education.*



***Index Terms*** — *Entrepreneurship, Role-play, Simulation, Telecommunications markets.*


## INTRODUCTION

When starting a career, many engineering graduates have serious behavioral mismatches and very limited knowledge about the activity sectors and businesses where they become involved. These circumstances can represent an important handicap in their careers and the resulting limitations can significantly impair their capability to play the roles that enterprises expect from them.

In addition, these weaknesses also do not favor the emergence of an entrepreneurial spirit among young engineers, restricting their ability to contribute to economical and social growth. Ultimately, all this can jeopardize their employability. Several reasons can be put forward to explain these situations:

- Engineering curricula are characterized by a strong emphasis on science and technology disciplines. This is an essential requirement to prepare professionals with the analytical skills that an engineer must have. However this preparation on propaedeutic and specific subject matters of each engineering field frequently is not accompanied by an effort to prepare students about equally important non-technical aspects of their profession. These shortcomings are particularly felt in relation to skills such as planning, organization and inter-personal communication. All this is further aggravated when they have to work within a team [1][2].
- Frequently, during their courses, students develop very little awareness about the outside world, namely about the markets where soon they will be looking for a job or fighting to keep it.

In other to gain a better understanding about the issues previously mentioned a study has been conducted over the last 9 years, encompassing approximately 300 students of engineering courses (higher education) and approximately 500 students of foundation courses (post-secondary education) [3].

The fundamental questions addressed by the study were the following:

- Student's representations with respect to the specific subjects of study of their courses.
- Representations of enterprises that received either young graduates or trainees from engineering and foundation courses.

Among the findings of this study where the following aspects [4]:

- Engineering and technology students receive tools for solving problems that they have never faced before and for which they do not have an adequate appreciation.
- Because of their limited real world experience, engineering and technology students have difficulty in understanding the practical applications of their studies.

Another frequent feeling among large amounts of engineering students is that they find that classes boring [5]. Our research [3][4], and the research of other authors [6], found that this is mainly due to the following causes:

- First, because of their limited real world experience, they have difficulty in understanding the practical applications of their studies, and
- Second, as a direct consequence of the traditional universities' teaching approach: they receive tools for solving problems that they have never faced before and for which they not have an adequate appreciation.

The research presented in this paper describes an experiment that has been active for the last two years that attempts to address the above shortcomings.

## APPROACH

According to Richard Felder [7], active and cooperative learning methods facilitate learning and skills development. Active learning means students do something in class "beyond simply listening and watching" [8]. Through discussion, questioning, arguing and brainstorming, students engage in active experimentation and reflective observation, key aspects of effective learning. Felder frequently uses realistic examples of engineering processes to illustrate basic principles. He reported the use of extensive cooperative (team-based) learning, both in and out of class, trying to get the students to teach one another rather than relying entirely on the instructor as the source of all knowledge. This resulted in significant positive effects on students' performance and retention, attitudes toward engineering as a curriculum and career, and levels of self-confidence.

Induction is a reasoning progression that proceeds from particulars to generalities. Research supports the notion that inductive teaching approaches promotes effective learning [9] [10]. This supports the implementation of problem-based approaches in engineering education.

The basic approach used in the presented study considers these literature findings and is based on the following ingredients:

- Team-based projects that focus on real-world problems.
- Definition of project ideas made with the contributions of practicing engineers from several companies that are invited to present some of their real-work challenges in a series of seminars.
- Projects designed around a situation where teams play the role of competing companies in a market place.
- Faced with a specific challenge (as will be outlined ahead in the paper) each team tries to identify possible solutions and must make its evaluation, both in technical and economical terms.
- Chosen solutions must be converted into a business case, with different teams playing the roles of competing companies in a marketplace.
- A didactic market simulator, *STIMULEARNING*©®, is used to create condition similar to those found in real markets and to convey experimental lessons transferable to the real world.

This leads to an atmosphere of project-based active learning combined with an interactive entrepreneurial atmosphere in the area of telecommunications engineering.

The critical factors for success in this game are team work, the dynamic features of a collaborative digital environment and a sound command of networking fundamentals: enabling technologies and services, business models, market structure, relevant players, consumer trends, environmental constraints, etc.

## *STIMULEARNING©®* FUNDAMENTALS: THE SYSTEM DYNAMICS APPROACH

*STIMULEARNING©®* is a didactic market simulator that can be used to make students familiar with the dynamics of a wide variety of economic sectors. The sector considered in this paper is that of telecommunications access networks but it can easily be transposed to other sectors.

The basic ideas behind this didactic simulator are explained ahead resorting to the following example:

- Consider a geographical area where a set of several telecom operators wants to invest in a new technology (eg: delivering fiber-to-the-home):

  *Set of Operators*: $\{O_i\}$

- Assume that the market adoption of this technology (supplied by whatever operator) follows the usual S-shaped logistic curve as depicted in the following figure:

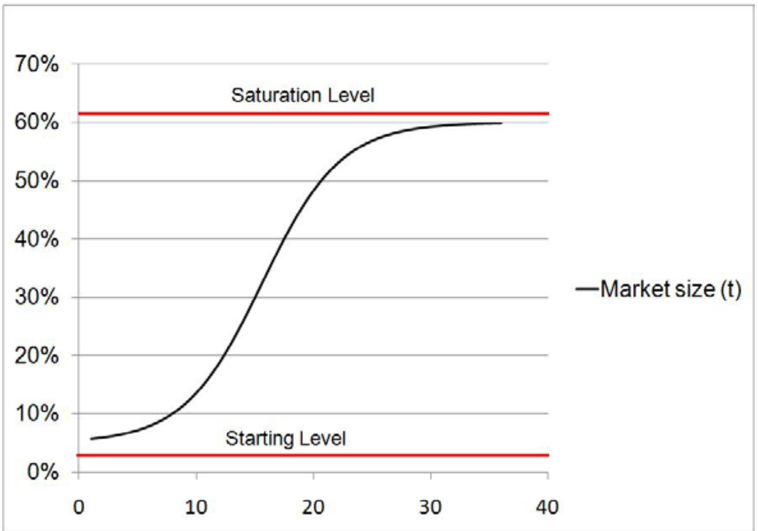


FIGURE 1
TYPICAL MARKET EVOLUTION IN TIME

- Assume that that at the beginning of the market process ($t$=0) the market share among the different operators has the following distribution:

  *Market share distribution among Operators* $Q_i$ *at* $t = 0 : \{M_i(0)\}$

- Assume that the perceived relative quality of operator $O_i$ as compared with the other operators at the beginning of the process is $Q_i(0)$:

  *Perceived relative quality of operator* $O_i$ *at* $t = 0 : Q_i(0)$

- Define Average Quality of the Market at instant $t$ as:

$$\overline{Q(t)} = \frac{\sum_i Q_i(t) \times M_i(t)}{\sum_i M_i(t)} \qquad (1)$$

- Define Relative Quality of Operator $O_i$ at instant $t$ as:

$$QR_i(t) = \frac{Q_i(t)}{\overline{Q(t)}}$$

- Define Quality Elasticity (for a certain operator, and a certain service or technology being offered) as the ratio between the percentage growth of market share arising from a certain percentage growth of quality:

$$E_Q \equiv \frac{dM\ \%}{dQ\ \%} \qquad (2)$$

- For each operator $O_i$, for time increment $t$ to $t+dt$, market changes can be calculated as:

$$dM_i(t) = E_{Q,i} \times dQR_i(t) \qquad (3)$$

- A set of dynamic equations for market evolution can be written as:

$$M_i(t) = M_i(t-dt) + dM_i(t-dt) \qquad (4)$$

- From this set of equations it is possible to calculate market share evolution.

For a specific example of a market with 3 operators, 10.000 users, and initial relative qualities and market shares given by table 1, the market share evolution over a period of 36 time units is given by figure 2.

| Operator | Quality of service | Initial market share |
|---|---|---|
| A | 10,5 | 70% |
| B | 11,7 | 7% |
| C | 11,2 | 23% |

TABLE 1
RELATION BETWEEN OPERATOR, QUALITY OF SERVICE AND INITIAL MARKET SHARE

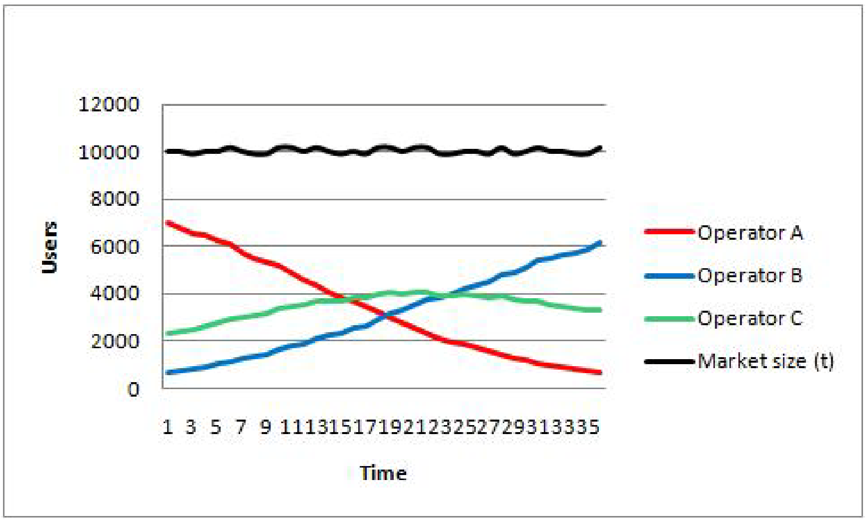


FIGURE 2
EXAMPLE OF MARKET SHARE EVOLUTION FOR 3 OPERATORS (WITHOUT THE INCORPORATION OF TECHNOLOGY/SERVICE ADOPTION EFFECTS)

Combining the resulting market share evolution in time with the logistic curve depicting the adoption of the technology/service by the market the end result becomes as shown in figure 3.

Figure 4 illustrates the concept of *STIMULEARNING©®*.

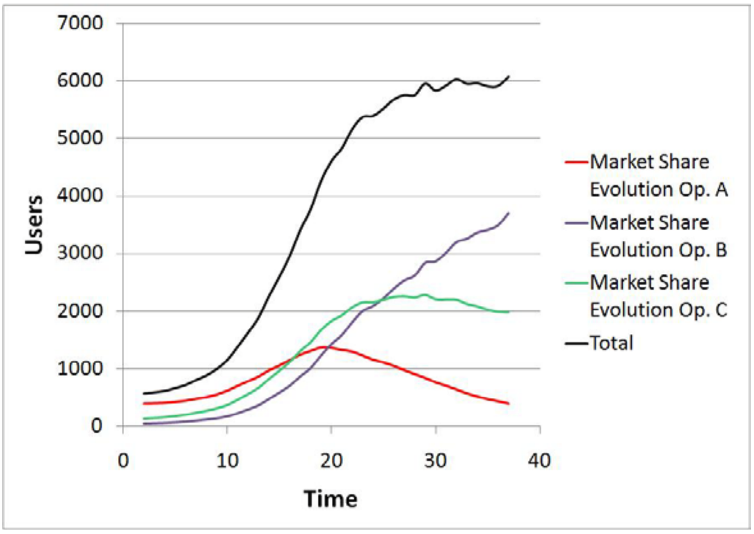


FIGURE 3
EXAMPLE OF MARKET SHARE EVOLUTION FOR 3 OPERATORS (WITH TECHNOLOGY/SERVICE ADOPTION EFFECTS INCORPORATED)

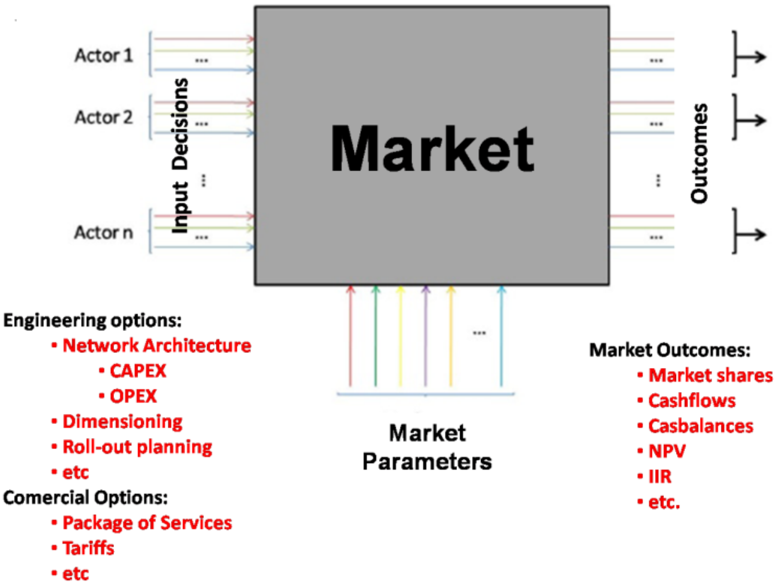


FIGURE 4
ILLUSTRATION OF THE *STIMULEARNING*©® CONCEPT

## RESULTS

To test and validate the approach described in this paper, *STIMULEARNING*©® didactic market simulator was given a trial in a Capstone Project in the 3rd year of an MSc in Electronics and Telecommunications Engineering (total duration: 5 years; 3 years 1st cycle; 2 years 2nd cycle).

The basic objective of this Capstone Project is to face students with the challenge of projecting an access network using up-to-date technologies (eg. Fiber-to-the-home) and evaluating the different architectures (point-to-point, point-to-multipoint, etc), different engineering solutions (active, passive, etc), roll-out strategies (market size estimates, completion, time plan of investments, tariffs, etc).

Until this trial, the Capstone Project was based on a set of lectures and tutorials followed by a very short laboratory assignment.

To estimate (quantitatively) the impact of the Capstone Project on student learning and understanding, during the last 3 weeks of a semester the class (45 students) was given an assessment test (multiple-choice questions) on access networks (which were the subject of study in the 9 preceding weeks) before the capstone project and the market simulator were introduced.

After this test the class had the opportunity to attend a seminar (1 hour) by an invited senior telecommunications engineer responsible for the access network planning in a major telecom operator and then it was split in 9 groups of 5 students for a short period (1 hour) doing hands-on familiarization with the market simulator.

This was followed by a period of 2 more classes (4 hours over 2 weeks) where the groups were organized in sets of 3 groups. In each set each group played the role of a telecom operator competing with the other 2.

Tablet lap-tops were made available for these sessions in order to facilitate interaction and discussion of ideas inside groups and among groups.

In the first of these 2 sessions every group started with equal market share as the other groups. Following a choice of engineering options related to the specific access network under consideration (architectures, active or passive network elements, market size estimates, expected competition, time plan of investments, tariffs, etc, *STIMULEARNING*©® produced the market share situation for every competitor, corresponding to half of the study period under consideration (as illustrated in Figure 3. During the period until the following class in the week after every group tried to devise possible strategies to either recover from the bad position where the first run had left them or to keep the advantage that eventually they had already obtained. The second run dictated the final results of the market game.

After this experience a test as similar as possible to the previous one (but not equal…) was given again to hall 45 students in order to measure eventual changes in student learning and comprehension. Figure 5 shows results of these tests.

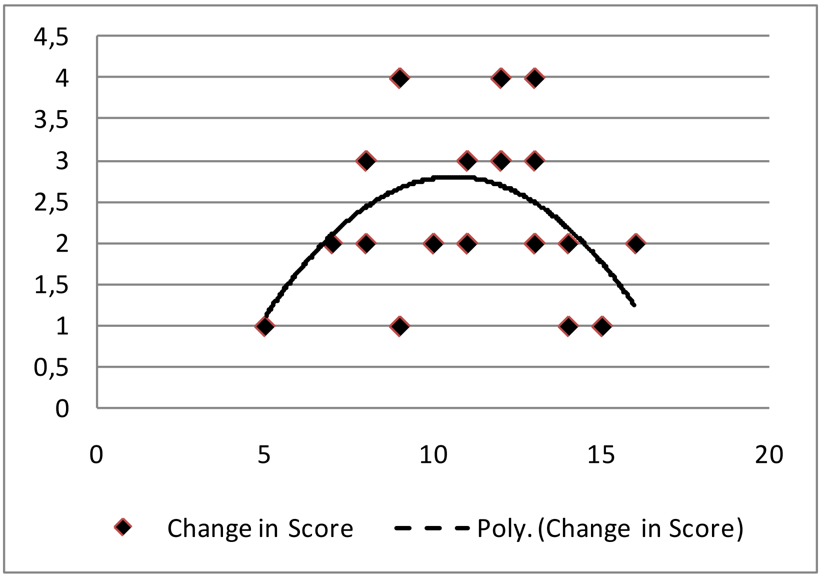


FIGURE 5
IMPACT OF THE *STIMULEARNING*©® CAPSTONE PROJECT APPROACH ON STUDENT OUTCOMES

Students also responded to a brief pedagogical questionnaire about the methodologies applied in the Capstone Project. The majority of respondents (63.02%) considered that Capstone Project is very useful for their professional future, 78,44% felted motivated with the methodologies applied, and 66,67% stated that it helped them to relate and integrate knowledge from different academic and non-academic contexts.

## CONCLUSIONS

The results obtained, in spite of referring to just one single run of the experiment (other will follow in subsequent years), were very encouraging:

- The class as a whole showed an average improvement of 2,5 points (out of possible 20), i.e.: approximately 12,5%.
- It was interesting to notice that the improvement was particularly significant in students with average marks, where the vast majority of engineering students do stand more frequently.

The above results were complemented by a set of (informal) interviews with a sample of 10 students (out of 45) in order to gain some feedback about how students felt with the experiment. The outcome of these interviews was generally very positive, stressing in particular the following aspects:

- The very positive effect of having a practicing engineers sharing with students some of their professional experience in problems very similar to those that they were facing in the capstone project (a typical case of "situated learning" [5]).
- Having the possibility to play with *STIMULEARNING©®* proved to be extremely useful to test and consolidate previous learning, to, help to gain better understanding of businesses and to improve teamwork.

## ACKNOWLEDGEMENT

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