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Active Classrooms: Role-Playing Experience in Telecommunications Engineering Education*

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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 the capacity of constructing their own work identity and ensuring their employability.

This paper describes the results of an educational project designed to promote improved learning among telecommunications engineering students and enhance their entrepreneurial competences. A didactic market simulator was developed and groups of students played the roles of competing market operators. This project showed an improvement of average marks, the development of teamwork skills, the consolidation of previous knowledge, and a better understanding of telecommunications business markets.

Keywords: role-playing; simulation; telecommunication markets; competences development

1. Introduction

The telecommunications sector faces tremendous challenges coming from the profound mutations that took place over the last decades in terms of enabling technologies, emerging business models and organizational structures. As result, companies frequently point out difficulties in finding graduated engineers equipped with the competences required by the new professional environment. Integrated vision of the telecommunications sector, sound scientific background and ability to cope with technological and organizational changes are some of the most frequent weaknesses pointed out. Some fundamental soft skills such as problem-solving, critical thinking, teamwork and communication have also been referred as increasingly important.

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 interpersonal communication. All this is further aggravated when they have to work within a team [1, 2]. In addition, it is also frequent that 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.

As a result, 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.

The importance of above issues is becoming more and more relevant at a time when vocational choices for the engineering profession in the western hemisphere have been reducing for more than a decade and technological and organizational transformations are taking place at an unprecedented speed. This situation creates new responsibilities on the part of Higher Education institutions. *Curricula*

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should match market needs, not only in terms of contents but also in terms of pedagogical approach. New learning processes should be attempted focused on the learner, captivating his interest and promoting active and autonomous competence development.

2. Diagnosis

In other to gain a better understanding about the issues previously mentioned, update curricula design and improve employability, an initiative has been conducted over the last 8 years, encompassing approximately 250 students of engineering courses (higher education) and approximately 500 students of foundation courses (post-secondary education) [3]. The fundamental questions addressed by this 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 results of this study where the following findings [3, 4]:

- As a direct consequence of the traditional teaching approach, 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. Frequent feeling among large amounts of engineering students is that they find that classes are boring [5].

The initiative that gave rise to this paper was launched as an attempt to circumvent the above problems, considering the following aspects:

(a) Motivation and vocational guidance: involvement of engineering professionals in actions of motivational guidance; promotion of study-work periods of students in companies;
(b) Curricula design: competence-based;
(c) Pedagogy: autonomous work and meaningful knowledge construction. The design and the results of this experiment are the subject of the following sections.

3. Active learning through role-playing

The main objective of the pedagogical initiative presented in this paper is the promotion of active and meaningful knowledge creation in engineering students. This initiative consisted in the implementation of role-playing activities, as innovative pedagogical techniques with the potential to transform theoretical concepts into an experiential format.

Educational role-plays engage students in learning about similar to real-world problems, and active learning, providing students opportunities for 'learning by doing, receiving feedback, continually refining their understanding and building new knowledge' [6]. These pedagogical techniques are more dynamic, more learner-centred and more experiential than traditional ones. They also help the development of professional identities.

The pedagogical strategies described ahead are currently taking place in the context of several courses in the area of Electrical Engineering (with majors in Telecommunications and Information Systems) at post-secondary, B. Sc. and M. Sc. levels (Bologna system). The initiative described represents an attempt to improve student's classroom involvement, attempting to bridge the gap between the engineering profession and the classroom, and creating conditions for better success rates.

The approach follows two phases:

(i) First, 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. Students engaged in weekly discussion sessions with practicing engineers and experts (industrial guest speakers) in order to exchange ideas and discuss career paths. The main objectives of these sessions were: provision of the 'big picture' about core characteristics of what telecommunication engineers do; exposition to positive role models; encourage questions and understanding.
(ii) Second, projects designed around a situation where teams play the role of competing companies in a market place. Competition initiatives among teams playing the roles of competing companies in an open market were delivered, in order to expose students to business dynamics, namely through 'betting' like situations similar to those present in real markets [7, 8].

This leads to an atmosphere of project-based active learning combined with an interactive entrepreneurial atmosphere in the area of telecommunications engineering. The role-playing competitions followed three steps:

- Faced with a specific challenge (as will be outlined ahead in the paper) each team tries to identify possible solutions and makes its evaluation, both in technical and economical terms.
- Chosen solutions must be converted into a busi-

ness 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.

A description of this market simulator is provided next.

4. StimuLearning©®

4.1 Training simulators

Training simulators are designed for education purposes, providing significant hands-on experiences that motivate and facilitate learning. It can offer experiences that resemble those of the real world [9] and, thus, gives students the opportunity to apply theory in an efficient, economic and interactive fashion [10].

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.

StimuLearning©® has been developed with the following requirements:

- Visually appealing and easy-to use.
- Capable of helping students. . . :
  - to learn how market dynamics works and are the engineering factors that influence market dynamics,
  - to understand the relation between technological choices and economic implications,
  - become aware of competition mechanisms.

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.

4.2 System dynamics

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

- Consider a geographical area where a set of N telecom operators wants to invest in a new technology (e.g.: delivering fiber-to-the-home):

$$\text{Set of Operators: } \{O_i\},\ i \in [1, N]$$

- Assume that the market adoption of this technology (supplied by whatever operator) follows the usual S-shaped logistic curve as depicted in the following Fig. 1 [11]:
- 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

$$\text{At } t = 0 : Q_i(0),\ i \in [1, N]$$

Assume that the perceived relative quality of operator O_i as compared with the other operators at the beginning of the process is $Q_i(0)$, $i \in [1, N]$:

Perceived relative quality of operator O_i, $i \in [1, N]$ at $t = 0 : Q_i(0)$, $i \in [1, N]$.

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

$$\overline{Q(t)} = \frac{\sum_{i=1}^{N} Q_i(t) \times M_i(t)}{\sum_{i=1}^{N} M_i(t)} \quad (1)$$

- Define Relative Quality of Operator O_i, $i \in [1, N]$: at instant t as

$$QR_i = \frac{Q_i(t)}{\overline{Q(t)}},\ i \in [1, N]$$

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

$$E_Q \equiv \frac{dM\%}{dQ\%}$$

- For each operator O_i, $i \in [1, N]$, for time increment t to $t + dt$ market changes can be calculated as:

$$dM_i(t) = E_{Q,i} \times QR_i(t) \quad (2)$$

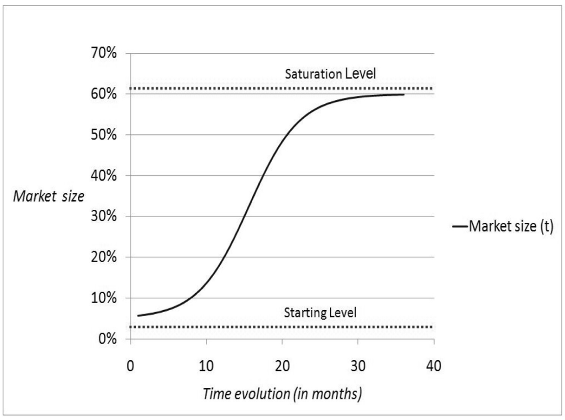

Fig. 1. Typical market evolution in time.

Table 1. Relation between operator, quality of service and initial market share

Operator	Quality of Service	Initial Market Share
A	10.5	70%
B	11.7	7%
C	11.2	23%

- Then, from the above a set of dynamic equations for market evolution can be written as:

$$M_i(t) = M_i(t - dt) + dM_i(t - dt),\ i \in [1, N]$$

- From this set of dynamic equations it is possible to calculate market evolution over time, assuming that changes do not occur in the relative quality factor among operators. If this is not the case, a new set of dynamic equations must be calculated.

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

In order to make simulations more realistic the simulator introduces a randomness factor in the dynamic equation.

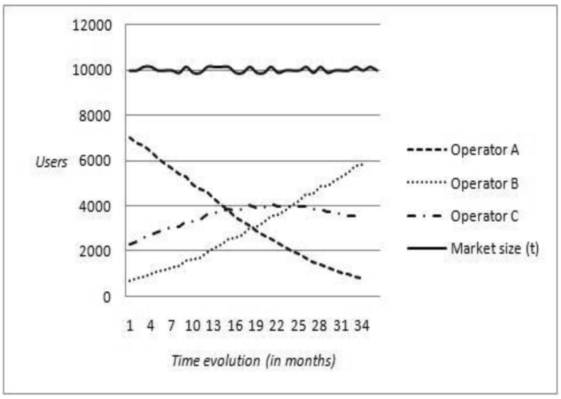

Fig. 2. Example of Market Share Evolution for 3 Operators (without the incorporation of technology/service adoption effects).

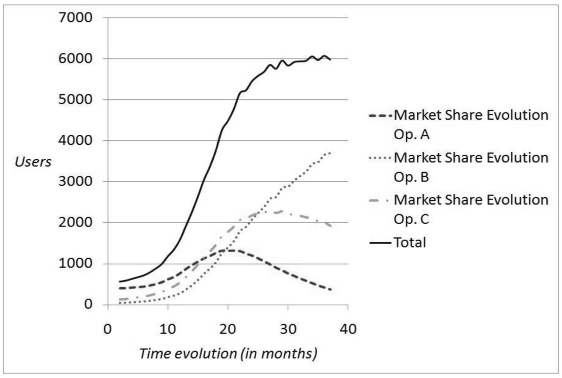

Fig. 3. Example of Market Share Evolution for 3 Operators (with technology/service adoption effects incorporated).

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 Fig.3.

With this characteristics *StimuLearning*©® has proved to be a very powerful didactic tool that can be used to make students familiar with the dynamics of a wide variety of economic sectors.

4.3 Test and validation

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 (e.g. 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

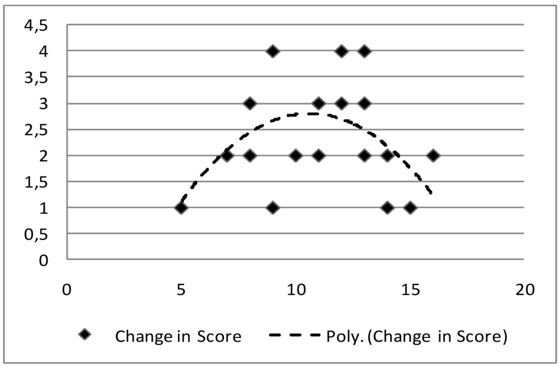

Fig. 4. Impact of the *StimuLearning*©® capstone project approach on student outcomes.

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 Fig. 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. Fig. 4 shows results of these tests.

4.4 Assessment of experience's impact on student's learning

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 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, to improve teamwork.

5. Conclusions and future developments

The initiative presented in this paper showed very positive results in students' motivation and commitment to learning, and also contributed to the development of project management, problem-solving and teamwork skills.

Observing graduates employability results over the last 3 years it has become apparent that the described approach is also having a very positive impact in terms of labour market acceptance.

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