STIMULATING LEARNING VIA TUTORING AND COLLABORATIVE ENTREPRENEURSHIP GAMING

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ABSTRACT

This paper presents results from a multidisciplinary program targeted at engineering education and at the development of entrepreneurial mind in telecommunications engineering students.
The basic concept is rooted in a capstone-like project with the following characteristics: (i) Creation of student awareness about real world engineering activities, involving engineering professionals and enterprises in selected classroom activities; (ii) Simulation of a business environment in capstone project classes; (iii) Market gaming around a set of business cases where students are organized in teams playing different professional roles (role playing); (iv) Linking the outcome of market gaming and associated business cases with syllabus topics and with practical issues resorting to engineering decisions that have to prepared based on technology choices, network design, market simulation and economic-financial analysis.
The results showed an improvement in average marks, the development of teamwork skills, the consolidation of previous knowledge and a better understanding of the telecommunications business markets.

KEYWORDS

Tutoring, problem based learning, entrepreneurship.

1. INTRODUCTION

The profound mutations that took place over the last decades in terms of enabling technologies, emerging business models and organizational structures challenges continuously the telecommunications sector and demands, more than ever, a competent and flexible workforce. The sector's companies look for graduated engineers equipped with the competences required by the new professional environment. However, a well succeeded recruitment is hard to achieve, as recent graduated engineers are considered not sufficiently prepared with knowledge and skills to face the uncertainties of the market. They frequently lack an integrated vision of the telecommunications sector, sound scientific background and ability to cope with technological and organizational changes. Some fundamental soft skills such as problem-solving, teamwork and communication have also been referred by companies' as increasingly important.

Higher Education institutions have responsibilities in preparing future engineers to work competently and deal with unpredictable challenges. Unfortunately, engineering curricula are still characterized by a strong emphasis on science and technology disciplines instead of more practical approaches. Science and technology are essential requirements to prepare students 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 soft skills such as planning, organization and inter-personal communication. All this is further aggravated when they have to work within a team. 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.

For many engineering graduates, when starting a career, the unsuitability of companies' demands and educational programs results in 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 [1] among young engineers, restricting their ability to contribute to economical and social growth. Ultimately, all this can jeopardize their employability.

This situation creates new responsibilities on the part of Higher Education institutions. Curricula should match industry needs, not only in terms of contents but also in terms of pedagogical approach. Learning processes should be focused on the learner, captivating his interest and promoting active and autonomous competence development.

2. EXPLORATORY STUDY

Over the last 8 years a study has been conducted encompassing approximately 250 students of engineering courses (higher education) and approximately 500 students of foundation courses (post-secondary education) [2]., in other to gain a better understanding about the matching between industry needs and curricula, and also to prepare future actions. This study addressed the following aspects:

- 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:

- 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 were boring [3]. Previous research [2] found that this is mainly due to the following causes:

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

In summary, many students don't develop meaningful knowledge and competences and this is caused by the adopted pedagogical approaches that don't promote active learning.

3. ROLE-PLAYING: PROMOTING ACTIVE AND MEANINGFUL KNOWLEDGE

In order to provide answers to the problems identified in the study outlined above, a pedagogical initiative was launched targeted at the promotion of active and meaningful knowledge creation in engineering students. This initiative is 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 basic concept behind it is rooted on a capstone-like project where groups of students play the role of telecommunication companies competing against each other resorting to decisions that they have to prepare based on sound engineering studies: technology choices, network design and dimensioning, market simulation and economic-financial analysis.

With this role-playing approach students are engaged in authentic real-world problems and active learning, having the opportunity of learning by doing, receiving feedback, continually refining their understanding and building new knowledge [4]. This initiative is intrinsically dynamic, learner-centred and more experiential than traditional ones. It represents an attempt to improve student's classroom involvement,

bridging the gap between the engineering profession and the classroom, attempting to contribute towards better success rates and improved employability. It also helps the development of professional identities.

The initiative followed two phases:

- 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.
- 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 [5].

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 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 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. DIDACTIC MARKET SIMULATOR

Training simulators are designed for education purposes, providing significant hands-on experiences that motivate and facilitate learning [6]. Additionally they can also offer experiences that resemble those of the real world and, thus, can give students the opportunity to apply theory in an efficient, economic and interactive fashion.

The work described in this paper was supported by the usage of a didactic market simulator that can be used to make students familiar with the dynamics of the telecommunications sector. It can easily be transposed to other economic sectors. Its structure, in its present state, is depicted in the following figure:

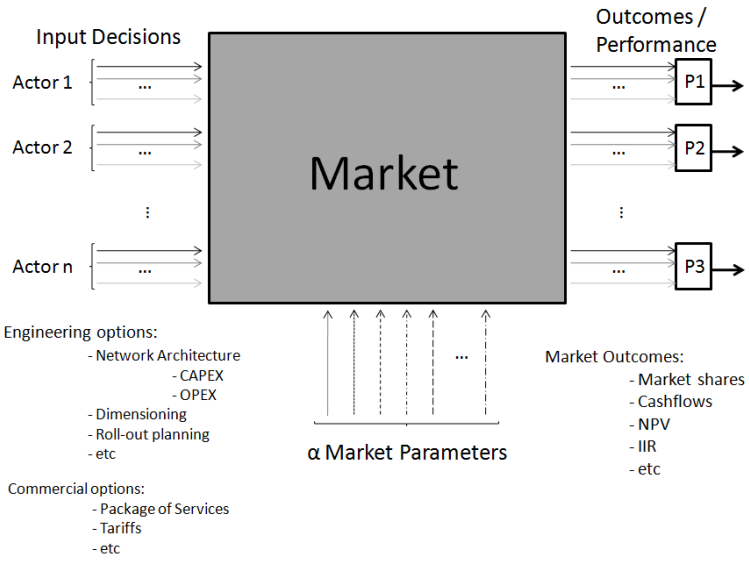

Figure 1. Didactic market simulator structure

4.1 Purpose of the Didactic Market Simulator

The simulator is designed so that students will learn how telecommunications engineering decisions (e.g., network architecture, physical media, bandwidth, latency) associated with marketing, economic and financial decisions (e.g., offered services, tariffs, competition among operators, etc) affect the overall network performance and the ways markets react.

In a preliminary phase Excel was used as the basic platform. This enabled some fine tuning of the mathematical model and also proved very useful for the determination of several parameters. At a later stage the implementation was migrated to a web environment supported by database and appropriate query languages.

The following figures illustrate some screen shots obtained with the market simulator in a web environment:

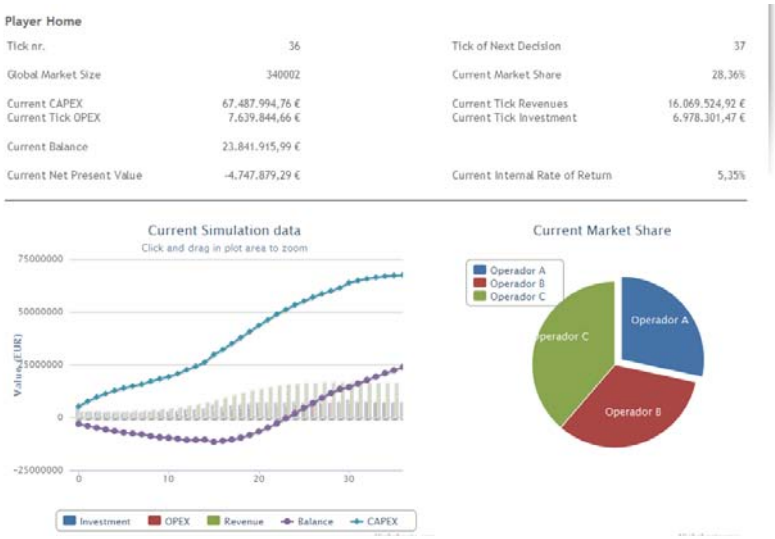

Figure 2. Example of screen shot obtained with the market simulator (investment analysis in an access network with 3 operators)

4.2 Test and Validation

In order to test and validate the approach described in this paper a series of experiments was trialed over the last two years. This was done in the context of 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, LTE, WiMAX, etc) and evaluating the different architectures (point-to-point, point-to-multipoint, etc), different engineering solutions (active, passive, etc), roll-out strategies (market size estimates, time plan of investments, tariffs, etc). In this work students are required to integrate knowledge and skills developed in other disciplines, probably over a period of more several years.

To estimate (quantitatively) the impact of the approach described in this project on student learning and understanding, during the last 3 weeks of a semester (over the last 2 academic years) , the class (45 students, average) was given an assessment test (multiple-choice questions) on Access Networks (a subject **not** specifically studied in the 9 preceding weeks, and which requires the integration of knowledge and skills developed in other disciplines, over a period of approximately two years before the capstone project) and the market simulator was 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. Here students had the opportunity to witness some of the challenges faced by a telecommunications engineer in

planning, designing and operating an access network under severe market competition conditions. At this point the class 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 working sessions (4 hours over 2 weeks) where the class was organized in sets of 3 groups. In each set each group played the role of a telecom operator competing with the other.

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,) the simulator produced the market share situation for every competitor, corresponding to half of the study period under consideration (as illustrated in **Erro! A origem da referência não foi encontrada.**). During the period until the following session, 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 an assessment test on Access Networks as similar as possible to the original one (but not equal…) was given again to all 45 students in order to measure eventual changes in student learning and comprehension.

Figure 3 shows the aggregate results of these tests over the period of 2 academic years.

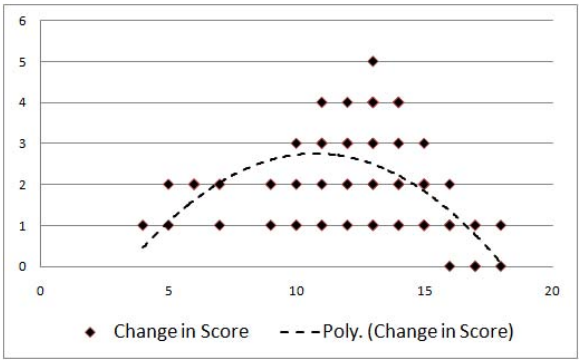

Figure 3. Impact of the capstone project approach on student outcomes

4.3 Assessment of Experience's Impact on Student's Learning

The results obtained, in spite of referring to just 2 runs of the experiment over the last 2 years (other will follow in subsequent years), were very encouraging:

- The classes, as a whole (2009-9, 2009-10) showed an average improvement of 2,06 points (out of possible 20), that is, approximately 10,3%.
- 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 both academic years, in order to gain some feedback about how students felt with the experiment. The outcome of these interviews was generally very positive, underlining particularly the following aspects:
- The very positive effect of having a practicing engineer sharing with students some of it professional experience in problems very similar to those that they were facing in the capstone project (a typical case of "situated learning" [3]).
- Having the possibility to play with the didactic market simulator proved to be extremely useful to integrate and consolidate previous learning, to help gaining a better understanding of businesses dynamics and to improve teamwork.

4.4 Assessment of Experience's Impact on Employers

Given the fact that the experiment was done with students attending their last year of the 1st cycle of the engineering degree (Bologna type) it was possible to track some of these students in their first employment. This was done with a group of 5 students that graduated in 2008-9. Results and is currently being done with 5 additional students that graduated in 2009-10.

As part of this exercise several interviews were made with responsible personnel of the employing companies following the first 3 months of employment of the graduates.

In spite of the limited statistical value that this limited number of enquires might have it is very encouraging to notice that, in general they seem to point out to the following: as compared to their company colleagues, test graduates exhibit better teamwork skills, show good ability to integrate and associate knowledge from different fields and reveal good understanding of the telecommunications business markets.

5. CONCLUSIONS AND FUTURE DEVELOPMENTS

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 classes as a whole (2009-9, 2009-10) showed an average improvement of 2,06 points (out of possible 20), that is, approximately 10,3%.
- 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 20 students (out of 90) 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 a didactic market simulator closely linked to the engineering variables present in a typical telecommunication project proved to be extremely useful to integrate and consolidate previous learning, to help gaining a better understanding about businesses dynamics and to improve teamwork skills.
- As compared to their company colleagues, test graduates exhibit better teamwork skills, show good ability to integrate and associate knowledge from different fields and reveal good understanding of the telecommunications business markets.

The implementation of role-playing activities proved to be a fruitful pedagogical technique with the potential to transform theoretical concepts into experiential outcomes. In this way, educational role-plays engage students in close to real-world learning, providing students opportunities for learning by doing, refining their understanding and building new knowledge. Improved employability is also a potential important result since graduates capability to play the roles that enterprises expect from them is significantly benefited.

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