Technology Based Entrepreneurship … an effective tool for promoting teamwork, creativity and innovation in students

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I. Introduction

Traditionally engineering and business education has been oriented towards preparing professionals for the private sector. Today this sector demands from the universities a new graduate with skills that go far and beyond the traditional skills and competencies. Today's graduates should be able to communicate their ideas effectively both orally and written, work in multidisciplinary teams, solve problems from a global and multilateral perspective, be entrepreneurs in the organization and have an understanding of the economic, social and cultural environments. These skills are indispensable to identify and capitalize on the opportunities that emerge in these environments. This requires a new approach in the professional educational process. This paper describes a strategy that the University of Puerto Rico at Mayagüez is following to contribute to this cultural change.

II. Why we need a new approach?

Today students are more conscious of the world around them. Therefore, they want an education that responds to their perceptions. Students validate their education and have the perception that their education is inadequate to manage the needs and business goals of industry. A fragmented curriculum does not satisfy this need. Students want an integrated education with a strong experiential component.

Industry recruits students with skills such as the ability to communicate effectively (verbally and written), to work in multidisciplinary teams, to have an entrepreneurial spirit, and with effective decision-making skills. The graduates should be aware of their cultural, social and economical environments (i.e. culture, language, diversity, art, etc.). Industry has stated that many engineering and business curriculums do not answer students' needs. The graduate should have a clear understanding of the need to be flexible when working with business problems. Flexibility here means being able to revise and to change the basis of decisions. This flexibility is essential to any business that wants to compete in a global diversified world.

Proceedings of the 2001 American Society for Engineering Education Annual Conference & Exposition

Some faculty members are not satisfied with the way they teach and develop professionals. They perceive through the media, their students, the newspapers and, other social indicators that there is a need to develop a complete professional.

National and international organizations such the National Science Foundation (NSF), the American Society of Engineering Education (ASEE), the National Research Council (NRC), and the Accreditation Board of Engineering and Technology (ABET) have emphasized that there is a need to approach education from an interdisciplinary perspective.

III. Proposed Educational Model

Motivated by the need to change the educational paradigm, a new strategy is proposed. This is supported by the structure and educational principles described in the following sections.

A. Foundations of the Educational Model

To satisfy the above-mentioned needs, a new educational model is proposed based on the following pillars:

1. **Creative and innovative thinking.** The new model should provide an educational environment that promotes creativity and innovation. Students should feel comfortable and should develop the ability to learn from past mistakes. New assessment methods should be established to give students the opportunity to explore different alternatives, be allowed to fail and to learn from their mistakes. In addition students should learn to apply solutions to problems in a creative way that also considers the limitations that the environment imposes and the psychological barriers that limit creative thinking.
2. **Multidisciplinary learning.** Students should be exposed to a deep understanding of their major fields but at the same time they should learn about other areas related to them. In the proposed strategy the areas of art, philosophy, ethics, economics and business administration will be touched upon.
3. **Hands-on experience.** In this strategy, the practical experience complements the traditional educational approach. Laboratories are synchronized with lectures. Field trips are scheduled where knowledge is applied. The student is exposed to multi-sensorial experiences that reinforce and internalize knowledge.
4. **Balance between knowledge depth and breadth**. Within the new educational model the student learns the foundations related to their field of concentration and is reinforced with exercises based on real problems. In addition to this the student is exposed to general knowledge that surrounds their field of concentration. This balances depth and breadth in areas of specialization. The student should thoroughly understand what he knows and should be aware of what he doesn't know.

5. **Learning activities that motivate.** Every learning process should be developed in an environment that is motivational. This promotes self-learning and keeps the student concentration at its highest level. In addition this makes teaching more efficient from the time and resource point of view.
6. **Continuous self-learning.** At the end of any program, the graduate should have developed the ability to learn by herself and to perceive the learning process as a continuous activity that extends beyond the university years. This is obtained through a process that exposes the student to basic research concepts such as library research, laboratory and field research, expert advice, drawing conclusions, and professional opinions. The graduate should leave the university with enough knowledge to guide him in the right direction when new problems arrive that require the acquisition of new knowledge.
7. **Self regulated model to respond with the environment needs.** For this educational strategy to effectively serve our environment (industry, government, academia, and the public) in a continuous form and at the same time be a robust model (that effectively responds to changes) it should have internal and external indicators that detect any differences between the proposed objectives and the generated product, i.e., the graduate. The model should be designed with a feedback mechanism that promptly recognizes differences between the way students are educated and the needs of the environment. The strategy should promote effective changes while maintaining the quality of the educational process.

B. Structure of the Educational Strategy

The structure of the proposed educational strategy is represented in figure 1. This model consists of three main educational activities: interrelated courses, the learning factory and outreach activities. The educational model involves students from different colleges. They come with different professional development expectations, they are seeking educational experiences that are different from the traditional structured education.

The University of Puerto Rico at Mayagüez has established three courses with an educational philosophy described in this document: *Technology Based Entrepreneurship* in the School of Business Administration, *Concurrent Engineering* in the Industrial Engineering Department, and *Product Dissection* in the Mechanical Engineering Department.

C. Technology Based Entrepreneurship

The Technology Based Entrepreneurship course has served as a laboratory to prove different teaching methodologies and to alter the way students and faculty members interact in an interdisciplinary environment. Due to the multidisciplinary nature of the problems studied in this course, it is necessary to implement a methodology to help students and faculty members in the problem solving process. This methodology should promote the interaction of interdisciplinary teams, foster an environment that encourages creativity and innovation, and, at the same time, allow students to achieve the proposed goals at the beginning of the course, i.e., the selection of feasible alternatives for the solution of a given problem. The faculty members of this course look at this methodology as a business assembly engine. This engine focuses the different technological and non-technological disciplines in the solution of a problem, which has the potential to succeed in the market. Figure 2 demonstrates this concept.

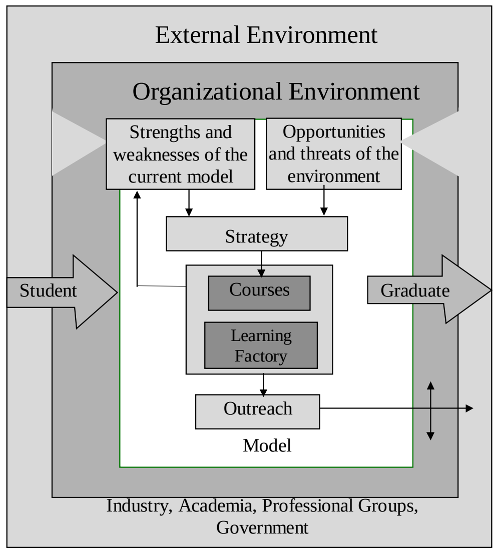
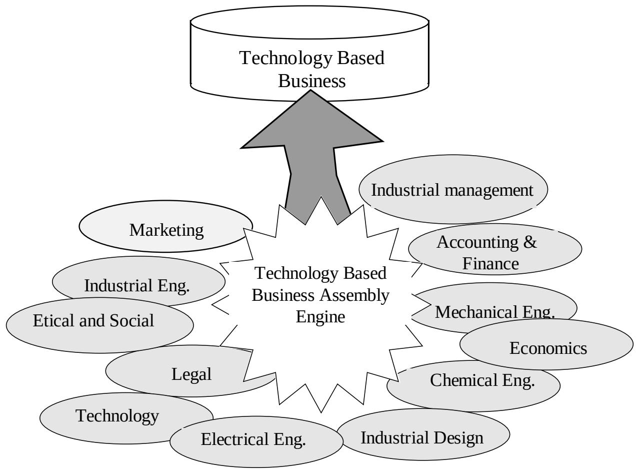


Figure 1. New model and its interaction with the environment

Figure 3 represents the model used to solve the problems that arise in this process of assembling businesses with a technological base. Faculty provides the basic theme that will serve as a support for the product generation process. Students start the process by analyzing opportunities in the market. Once they identify a niche in the market, they use the model to focus their multi-disciplinary knowledge in the search and selection of creative solutions. These solutions should be technically feasible and economically viable. Figure 3 shows a mechanism that promotes an environment where failure is not penalized if the student can demonstrate that he or she learned in the process. The model is based on a combination of methodologies.[1,2,3,4]

IV. Experience with the Technology Based Entrepreneurship course

The Technology Based Entrepreneurship course demonstrated the validity of the proposed model to students, faculty members, university administration and other stakeholders. This course is designed in such a way that the student enjoys the educational process. It promotes a challenging, creative, and innovating environment. The course is developed within a multidisciplinary perspective with balance between breadth and depth, its technologically strong, uses a convergence methodology to manage interdisciplinary groups, its based on hands-on activities, requires continuous improvement, and motivates the students to explore beyond their field of knowledge.



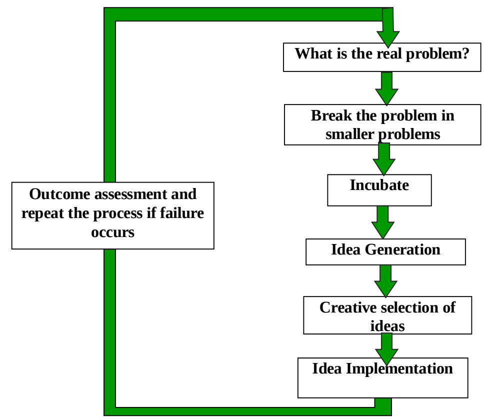


Figure 2. Interdisciplinary Interaction **Figure 3. Model to solve problems**

Key success factors for this course are the following: it is offered by a team of faculty members from the College of Engineering and the School of Business, it requires the conceptualization and development of an idea based on a design methodology; it requires balancing technical feasibility with economic viability and commercial potential. During the implementation phase students should consider how people think under different conditions and how they solve the problems. This course also teaches problem solving. Naturally this represents a challenge for faculty members because this implied a change in the educational culture. It implied to learn from other fields, to communicate our new model to the university community, industry and government, to create in them an understanding and to receive feedback of how we were realizing this process and consequently to measure the success, the problems, and the failures.

This course incorporates the concept of concurrent education. This involves the use of a intended syllabus and the simultaneous development of some labs. It starts with a basic structure proposed by the faculty members to keep the perspective of the course and to guide it through the semester and providing some structure. As the course evolves, students demand a revised structure, that is, new concepts and activities are added according to the circumstances that develop within the course. For example, the creation of interdisciplinary groups imposed restrictions to teams in the problem solving process. As soon as the students discovered their need in terms of skills, tools and values to solve the problems, they demand lectures or activities to learn them. Because students are working with new and real problems, it is very difficult to understand all the avenues that the course could take and therefore difficult to include them in the initial design of the course. Faculty and students build the final methodology as the course progresses. This requires a basic syllabus with enough flexibility to incorporate these changes (see Appendix).

The proposed methodology in the syllabus is geared toward designing new products and processes or towards improving existing ones. It is also presented as a methodology to solve problems under different disciplines: engineering, ethics, management, and marketing. At the same time it provides a framework to generate the desired outcome(s) at the end of the course. In this course we have combined key success elements from other methodologies for problem solving, product development and the creative process. Figure 3 represents the problem solving methodology. In the design of this course we have incorporated an interdisciplinary perspective. The following features have helped us to achieve this objective:

1. Interdisciplinary faculty members (more than 10 faculty members from Mechanical Engineering, Industrial Engineering, Electrical Engineering, Chemical Engineering, marketing, management, accounting and humanities) developed and assessed the course
2. Interdisciplinary student teams
3. Technologically interdisciplinary problems within a business environment to simulate a real business setting

This interdisciplinary focus presents challenges to faculty members, students and university administration. For example, it requires many additional hours by the faculty due to the extra requirements for the preparation of the course, to the flexibility and dynamics of the course and to the student-course negotiation process. For the faculty members this also implied an interdisciplinary learning process to present the material in a coherent way. For example, the engineering faculty members had to learn to appreciate the management and business components as well as the demands of the market. At the same time the management and business faculty members had to understand and appreciate the engineer's goal of optimal design. In this course we seek to balance these two approaches to manage the business efficiently. Special emphasis is put on designing lectures that consider the different levels of understanding that the student brings to the course due to the variety of backgrounds.

This course presents students with a different educational process. Even though faculty attempts to use a general vocabulary, some conferences can be technical. Also, working in interdisciplinary teams can present real difficulties. For example, when students discuss the feasibility of manufacturing a product, they should consider alternative materials, different processes, available technologies, quality assurance, and safety. Some of these concepts may need explaining.

The university administration has challenges as well. Administrators are not oriented towards the interdisciplinary nature of the course and constraints the implementation of the course. For example, how do administrators treat a course that requires different levels of involvement of several faculty members, and how do they justify it from a budgetary point of view. However, our experience has been positive and very rewarding. The cross-fertilization process established through this course among various faculties has been very interesting. Faculty members have learned to look at their area of expertise from a different perspective. For example the business faculty members are more aware of the technological restrictions present in business decisions. Engineering faculty better understand the need to include the voice of the consumer in the design of a product or a process. Both groups better understand how to include the technical and non-technical factors in the process of creating products and managing a business. Student feedback from different assessment processes has been very positive and encouraging. Many students emphasize that this is the first time that they have worked in interdisciplinary teams. The opportunity to participate in the design of the course has been stressed as a very important element of the learning process. The students value greatly the opportunity to participate in the learning process.

V. Conclusions

Preparing professionals for the private sector has traditionally been the focus of engineering and business education. Presently this sector demands graduates with skills and values that go beyond technical preparation. Engineers should be able to communicate, work in multidisciplinary teams, solve problems from a global and multilateral perspective, and demonstrate an entrepreneurial spirit as well as sensibility to the cultural social and economic environment. These skills are essential to take advantage of the opportunities that emerge in the environment. The Technology Based Entrepreneurship course is an effective strategy to demonstrate this change in educational paradigm. This strategy is built from an educational process that is creative, innovative, and multidisciplinary, with a hands-on approach, from a technological point of view and providing a balance between depth and breadth. The foundations and methodologies of this course have propitiated similar initiatives in other departments in our university.

Acknowledgement

To incorporate the concept of E-Teams, the authors are currently offering the Technology Based Entrepreneurship course through a grant from the National Collegiate of Inventors and Innovation Alliance (NCIIA).

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APPENDIX

Proposed Course Outline – Spring 2001
ADMI 3125: Technology Based Entrepreneurship

Day	Topic / Activity	Lecturer	Milestones
1	Course overview + entrepreneurship, course documentation, group formation, team building (TB) assignment ("pre-test")	J. Vélez	
2	Team building lecture & review assignment. (Team building exercise every 3 Tuesdays)	J. Vélez	Team building assignment
3	Intro. to Product Development Process (PDP) & Market Analysis	M. Torres & J. Pabón	
4	Market Analysis (MA) & Consulting	J. Pabón	
5	Seminar on Intellectual Property	F. Irizarry	Problem Id.
6	Presentation: Market Need (Theme: IT related innovations?)	Staff	
7	Problem Description PDS	M. Torres	Market Analysis
8	Workshop: Creativity & Innovation (10:30 - 1:30)	M. Torres	
9	Consulting: Finishing PDS	Staff	
10	Proposal preparation	J. Vélez	PDS
11	Consulting: Idea generation	Staff	
12	Idea Selection	M. Torres	Ideas
13	Workshop: Patent Search	F. Irizarry	
14	Consulting on the ideas and idea selection	Staff	
15	Lecture on Patent process and legal aspects.	F. Irizarry & H. Hoglund	
16	Presentations of the ideas: Focus group I	Staff	
17	Presentations of the ideas: Focus group II	Staff	Selected Idea
18	Proposal presentations I	Staff	
19	Proposal presentations II	Staff	Proposal I
20	Workshop: Prototype development	M. Torres & J. Cruz	Proposal II
21	Product Costing	D. Hernández	
22	Development of Business Plan	J. Vélez	
23	Consulting: Prototype development	Staff	
24	Development of Market Plan	J. Pabón	Business Plan
25	Consulting: Business Plan	Staff	
26	Consulting: Market Plan	J. Pabón	
27	Seminar on Intellectual Property: Business Method & Algorithms	H. Hoglund	
28	Consulting: Intellectual property	Staff	Market Plan
29	Consulting: Putting the finishing touches I	Staff	
30	Consulting: Putting the finishing touches II	Staff	