Innovative and Entrepreneurial Approach in Chemical Engineering Education.

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Abstract

The need for chemical engineers of a new kind with wider knowledge in management, assertive and entrepreneurial has become a reality for Mexico. One can see increasing difficulties in obtaining a job or demands to deal with personnel and teamwork problem solving. Chemical Engineering faculty members in 1996 integrated two last semester courses: Chemical Plant Design and Project Management and Evaluation so that students could develop a single engineering and economics team project integrating knowledge and abilities, developing negotiation and decision making skills. Through the four-year time frame this effort initiated with students selecting ideas mostly from a pool provided by faculty and local businesses that had displaced to selecting mainly their own business ideas. This method has worked providing close to real life consulting. Finally these projects have been well received by firms searching for fresh solutions and local business people aiming to help potential entrepreneurs.

Keywords: higher education, engineering education, project management, interdisciplinary, entrepreneurship.

Introduction

Perception of new demands for engineers in southern Mexico came from participation in several conferences about the engineer for the 21st century, round tables to analyze trends, and opinions of firm owners and executives. Most of them consider a shift towards fewer jobs inside current firms or government, more opportunities to create small firms to supply products and services, and even inside firms a more intrapreneurial and innovative behavior.

In the 1990's, main models for quality in higher education specific in teaching engineers mentioned recommended characteristics of chemical engineers (Romero O., 1995). Among them: creative, entrepreneurial, capable in using modern tools, technical capacity and interaction with other professionals. Besides, the curricula and program should develop student capacity for practical solution of technical problems and societal related ecological aspects. Usually those subjects are not reachable through technical or economics courses alone.

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Abetti (1992), wrote about the infrastructure to develop technological entrepreneurship, mentioning key elements of infrastructure, such as, the availability of business entrepreneurs and managers as well as skilled factory and office workers networks to obtain the required human resources. Further he concluded for growth of technical entrepreneurs in an area, initial efforts should concentrate on developing weak elements.

Zaid (1995), discusses the lack of new entrepreneurs and depletion of entrepreneurial tissue in Mexico. He thinks it is an outcome of decades of paternalistic conduct and bureaucracy mainly from the government, shifting previous self-employment pattern of Mexicans.

With the above information in mind, two faculty members analyzed the last semester curricula where two courses (Chemical Plant Design and Project Management and Evaluation) demanded final project; both covered making brief documents. These courses have the potential for exploration or development of new ideas coming from applied research or businessmen. Professors chose to integrate both courses for the 1996 class trying to align the education of senior students with a mixture of managerial and technical capacity in addition to entrepreneurial development, therefore students would become modern engineers and the cells that could rejuvenate entrepreneur tissue. Course integration was quickly implemented thanks to faculty freedom to choose teaching methodology at our university.

In detail, some of the expectations were to help the education of modern engineers by a combination of practical problem solving, development of team jobs, interpersonal abilities and integral use of technical and managerial tools, by means of the project formulation. An additional subject was student practice of presentations facing evaluation boards. It was accomplished in one to two sessions presenting project advances and a final presentation to an assessment group formed by academics and businessmen. They considered the idea, degree of innovation, project complexity and size, besides individual student characteristics like ability to convince the audience –to sell the idea-, answering questions and management of rejections.

The authors have been in contact with experiences and ideas of Koen and Morel in two recent papers, and later presented ideas that reinforce our choice.

Koen(1999) says entrepreneurship can be taught. From a pedagogical overview students need to understand key success factors associated with successful ventures, to develop an awareness of the corporate and political environment affecting corporate venturing, to obtain support of an executive champion in the company, provide students in preparing business cases, and provide students with support in preparing the final project.

Morel et al.(1998) writes training of engineers adapted to small and medium enterprises (SME) requirements need transformation of the roles played by the partners according to: close collaboration with local and regional SME. These firms need engineers with double competence: temporal competence that means managing short term while considering long term and spatial competence that is managing and developing all components of an industrial system, this means manufacturing and businesses competence.

Background

The Chemical Engineering School is located in Merida, the capital of Yucatan State in Southeast Mexico. Yucatan State has more than 3000 firms producing food and feed, another 1000 in the manufacturing industry, around 130 assembly exporting firms (maquiladoras) mainly producing clothes and garments, and 97% of the firms are SME. Honey, vegetables, fish, sisal fiber, pork and poultry producers and slaughters, and orange juice are remarkable agri-businesses that export more than 50% of production. Other important industries are hospitality and tourism, trade and commerce, and services like health, medical, educational and financial services.

Enhancement of infrastructure to underpin industries covers new power plants –more than 1000 M Watts-, roads and highways, telecommunications, ports and a rebuilt international airport in addition to small local airports. All subjects mentioned before contribute to keep Yucatan as a prominent state for South Mexico.

The undergraduate chemical engineering program is more than three decades old and has a presence in the region through both alumni and knowledge diffusion activities among industrial firms and national and international associations. In the same school exists an acknowledged graduate program on Food Science (MSc.) and a graduate certificate program in Management of Technology, developing research in both areas.

The school is located in the heart of the main industrial parks, facilitating early interaction of students and employers. In several stages, this interaction has been promoted dealing with different programs for undergraduate students:

- Practice in industry in 1980's
- Work experience, meaning part time job in one local firm in 1990's

These efforts have been considered successful and were well seen by executives and firms owners.

Recently the creation of entrepreneurial / intrapreneurial spirit in students has been recognized very valuable, and conducted to the creation of "young entrepreneurs program" where students from second year an on work in teams of five to ten participants, usually from more than one school, to develop and commercialize a product. This happens during a period of time of ten months.

Case Description

The courses Chemical Plant Design and Project Management and Evaluation were taught separately to students of the 10^{th} semester of chemical engineering, they finished both courses elaborating projects that most of the times were different for each course.

In 1995, faculty teaching these courses analyzed the possibility to request students a single more in depth project that covers both courses. Then, to move the order of presentation of some subjects was seen necessary, in the case of process design and equipment selection to

match technical aspects of project formulation, and economics of plant design in relation with the start of investment calculations and financial evaluation. The Project Management and Evaluation course was updated including several topics among them: intellectual property, licensing and patents, product innovation, technology life cycle and technology transfer. The Chemical Plan Design was updated by that time to include more software, optimization methodologies and process simulation tools.

To proceed with the new approach, exists the necessity to look for projects or ideas to develop that cover the requirements of both courses. In the case of Chemical plant design the project shall include process considerations and equipment calculus, so just service projects were rejected, also some manufacturing projects lacking of process or separation operations.

The procedure was informed to 1996 class at the beginning of the semester, they were asked to form teams of two or three members and that projects have to develop close to commercial projects. Besides, it was expected the presence of executives and local advisors lecture around three times during the term, two to four consultants or executives participate in the evaluation. Evaluation covers intermediate and final presentation in addition to the document.

At the beginning was clarified that in classroom students will be taught the basics of both courses, considering how to integrate knowledge from former courses. They will have to do most of the job, for specific project considerations would ask for mentoring, and at the end of the semester they will have to present a document and to defend their project facing an assessment panel with internal and external evaluators.

Subjects in above paragraphs were considered to promote plan and scheduling for the assignment, internal team adjustment, negotiation, own decision making and entrepreneurial behavior.

In 1996, faculty contacted industrial advisors and firms that usually ask for lab services and transmit them the idea; they provided a set of ideas or projects to develop and students choose between them –four projects- and only one team decided to develop its own idea. Faculty members teaching mentioned courses are in broad contact with practical engineers, local advisors and executives, this fact facilitated to capture the interest of a number of people inside local firms and business associations.

In 1997, were eight teams, 23 students and two projects were ideas of students, in 1998 were five projects and two projects were student ideas and finally this 1999, were five projects and three were student born ideas. In the following table is presented an analysis of the projects. The relative small number of projects per year is a consequence of class size usually around 15 people.

Table 1. Projects developed 1996 to 1999.

Year	Projects characteristics	Observation
1996	Agribusiness ---2 Process plant---2 Manufacturing- 1	Four projects intended solutions for local firms One was student initiative
1997	Food/feed --------5 Manufacturing – 2 Process plant --- 1	Five projects presented solutions for local firms, where one (concentrate of passion fruit) conducted to installation of a new firm, other was an exploratory study for the new option of fish culture. One project realized the industrial process and economic evaluation of one scientific research output. Two projects came from students business ideas.
1998	Food / feed ------ 4 Manufacturing –- 1 Pollution control –1	Four projects were solutions for local firms; one supported the evaluation for a canning plant, other manufacturing of electric plastic outlets and one dealing with effluent treatment -maize process for traditional tortilla-. Students' ideas were for the industrialization of local fruit "pitahaya" and production of fine smoked ham.
1999	Process ---------- 2 Food & beverage – 3	Two projects were solutions for local firm or government program to help less developed municipalities Three were students' ideas, where one has its origin from research.

In all of these years, the evaluation panel was integrated for at least three faculty members, one or two managers or executives of local firms and one or two managers of local business associations. Presentations are opened to local community, making of their knowledge through student interviews with the media, trying to create in the student perception of recognition.

In the following paragraphs main projects are presented more in detail.

Among local firms exploratory and solution development projects to mentioned are:

- Product development and plant modification for new presentations of table salt, where the new product was fully developed by the firm and now is in the market
- Passion fruit juice and concentrate, the basis for a new plant linked with the plantation of this fruit, students were hired by the firm.
- Canning factory, was the basis to proceed with the detailed project.
- Plastic outlets for electrical installation, served for investment evaluation in the firm.

- Jack bean protein concentrates and starch, is still in consideration for support from agricultural association, to refine the project and investment.
- Fish culture, has attracted the attention of government.

Projects from student ideas that would become new firms:

- Pitahaya products were in the market around one year and would be promoted for State Government.
- Smoked ham of high quality, the firm was in operation around eighteen months.
- Dried habanero pepper, students have been reached for two local firms interested in the technology.

Last three projects and passion fruit one were part of the young entrepreneur program.

Some of these projects have been presented by their authors in national and international forum, specially jack bean protein concentrate, tropical fish culture, passion fruit juice and concentrate, pitahaya concentrate.

Student ideas have increased as percentage of the projects over time. The interest of the students for the schemes of industrial protection is more pronounced, some of them have look for schemes of protection but only two teams (one in 1998 and other in 1999) have developed formal search and contacts. Some students commented, as I know I have to do a project that is expected to be complex and that we have to handle ourselves, I prefer to explore an opportunity we would develop some time from now.

Student involvement to look for up to date and specific information has evolved in the form of participation to look for specific lecturers and a growth in the number of references from internet and databases, as a support for projects.

Discussion

To implement integration of courses was possible in short time because Universidad Autonoma de Yucatan permits faculty to adjust teaching methodology with minor bureaucratic requirements.

After four years of work we believe that most of the expectations like entrepreneurial behavior, awareness of society problems, skills for team work, use of new information tools and software, problem solving and decision making were worked on. Besides we have gotten extended contact with businessmen and developed awareness of business opportunities.

Specific observations are:

- Teamwork and increment of self-learning was accomplished, having only problems with one team that couldn’t manage individualities.
- Responsiveness to societal requests was reached as students worked in projects for treatment of effluents or transformation in by-products and combination of small food firms to support poverty alleviation.

- Entrepreneurial behavior increments as percentage of student idea projects.
- Even with students requesting more information through Internet and interviewing managers in local and national firms, exists a lack in interaction with professionals of different disciplines.
- Most successful projects happened when students participate in the young entrepreneurs program.
- Use of new information was covered through updated courses and search in Internet and databases.
- Assessment from businessmen.

Conclusions.

The initial expectations and goals were achieved supporting the formation of chemical engineers more aware of business opportunities, and sensitive to provide technical solutions to community situation. Students appear to increase vision for new products and some are interested either to initiate the venture or develop technology and commercialize. Successful projects linked with young entrepreneur program have a partial explanation in two facts: by the time senior students reached 10^{th} semester they have started the entrepreneur program; second this projects come from bigger teams. One problem to extend this approach is only a fraction of the senior students decide to enter in the young entrepreneurs' program.

The experience indicate these projects are a good way to explore economic potential of theoretical and applied research, they help to expand firm-university linkage that increase confidence and could expand other linkage activities.

Near future we plan to explore the possibility to develop further interdisciplinary integration with students of Economics or Accounting Schools.

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