Building bridges between academia and industry for Industrial and Systems Engineering in Latin America

Ángela Patricia Anaya Salazar[1], Mauricio Cabrera-Ríos[2]

Abstract – Collaboration between academia and industry is not the norm in Latin America. This happens even though many academic programs require a period of working experience to obtain a degree. The concern is that work experiences both at the undergraduate and graduate levels are not sufficiently posed as technical problem-solving endeavors. It is important, then, to disseminate stories of successful cases in Latin-American countries as well as to describe how these could be marshaled. In this manuscript, two working schemes geared to build such liaison are described in detail. One of them relates to a systems engineering/operations research practicum program at the graduate level in Mexico and the second one discusses an industrial engineering experience at undergraduate level in Colombia. Difficulties on the development of these programs and how they were overcome are discussed for each case.

Keywords – Industrial Engineering, Academia- Industry Collaboration, Case Studies in Latin America.

INTRODUCTION

Technological transfer from academia to the industry is expected, encouraged and, ultimately, set into practice in developed countries. In the case of Latin America, universities are perceived to focus more on their own operation politics rather than providing an environment where industry can benefit from academic support for problem-solving and where students can benefit from applying what they learn in classrooms.

University research has been shown to improve industrial competitiveness and should be regarded as an agent of growth (Salter & Martin, 2001). In spite of this fact, a limited number of firms take universities as a source for information and knowledge (Laursen & Salter, 2004). The depth of the application of Engineering knowledge is correlated to how effectively the training offered by the universities matches the needs of the industry. Because, as described by Hansen and Lehmann, universities *educate decision-makers of tomorrow in both public and private sectors* (Hansen & Lehmann, 2006); it is critical to establish linkages between academia and industry to foster sound practices grounded on scientific methodology and aimed to have a positive impact in society (Nagy & Robb, 2008).

Several successful collaborative efforts are reported in the literature. For example, the development of a region attributed to the service provided by the university as an innovation-promoting knowledge hub (Youtie & Shapira, 2008). In Taiwan, the National Chiao Tung University established an office of Research and Development in order to commercialize research and manage the know-how from university to industry. The National Taiwan University also developed a Commission on Research and Development to help faculty members and students to commercialize their research results and to create friendly environments towards the development of small-medium sized business (Mathews & Hu, 2007). In Spain the Technical University of Catalonia took the path of sustainable development by integrating the university activities to the society needs (Ferrer-Balas *et.al.*, 2009), posing an example of how productivity, research, and societal benefits can be put together.

This type of collaboration helps both parties to get advantages, students learn how to apply the concepts taught in classrooms and industries get the transfer of new technologies. The transfer has key stakeholders who make the process possible (Siegel *et.al*., 2003): (1) University scientists, who discover new technologies, (2) University technology managers and administrators, who serve as links between academic scientists and industry and manage the university's intellectual property, and (3) Firms/entrepreneurs, who commercialize university-based technologies.

Industrial funding generates an increase on the number of projects with collaboration between university professors and companies, research institutes and colleges in the region, which leads to publications and commercialization of products as benefits for all the parties involved (Gulbrandsen & Smeby, 2005). Furthermore, the relationships between university and industry should generate value in the terms of the potential to diffuse knowledge, which leads to positive effects in the economy (Giuliana & Arza, 2009).

Shortening the distance between academia and industry should result in a better translation from theoretical knowledge to true added value for the productive entities. It is the perception of the authors that the collaboration between academia and industry in Latin America is simply not strong enough. When talking to colleagues in both sides of the issue, this situation tends to be the rule rather than the exception. This also tends to be true both for undergraduate and graduate

[1]Universidad San Buenaventura-Cali, Cali, Colombia. Email: apanaya@usbcali.edu.co
[2]University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico. Email: mauricio.cabrera1@upr.edu
Note. The manuscript for this paper was submitted for review and possible publication March 11, 2011, and accepted for publication on May 4, 2011.
This paper is part of the Latin American and Caribbean Journal of Engineering Education, Vol. 5, No. 1, pp. 7-11, 2011.

education. Some of the historically perceived factors that might help explain this collaboration gap in Latin America are the lack of appreciation of education as a transformative force, as well as the lack of innovation culture in the industry. Also, as explained by Carvalho and Etzkowitz, Latin America has a history emphasizing the university's political rather than economic role in society (Carvalho & Etzkowitz, 2008). The idea that the university should play an economic role is a relatively new one. In fact, universities in Latin America are the primary employers for researchers; Thorn and Soo, explain that for countries as Argentina, Brazil, Chile, Colombia and Mexico, more than 60 percent of all researchers are employed by universities (Thorn & Soo, 2006). This leads to a need for connecting academic capability to industrial needs to generate innovation and technical competency.

In this work, experiences on building schemes to establish a successful liaison between academia and industry are presented. The cases involve a graduate program in Systems Engineering –with a focus on Operations Research- in Mexico, and an undergraduate program in Industrial Engineering in Colombia.

1. THE MEXICAN AND COLOMBIAN CASES

This section describes the experiences in two Universities, one from Mexico and the other one from Colombia. In both places, the authors perceived a gap between university and industry despite the existence of industry-related practicum requirements for students or offices for managing the contact with industry.

1.1 THE MEXICAN CASE

Graduate programs in Systems Engineering in Mexico are rather few, especially when looking for a focus on Operations Research. In fact, operations research courses are usually embedded in more general areas such as Management or Industrial Engineering. When preparing a course within the Systems Engineering/Operations Research (SE/OR) curricula, it is almost impossible to find case studies carried out in Mexico that can be discussed during the course. Also, although many undergraduate majors throughout the country have incorporated some knowledge on SE/OR, it is very difficult to find professionals practicing the discipline in the industry. One possible explanation is that, if students with SE/OR training do not have the opportunity to apply theoretical knowledge to real problems, then their diagnosis capabilities will not develop. This will make them overlook the many problem-solving opportunities that arise in the day-to-day experience in the industry. On the other hand, if the industry does not get a feeling for what the discipline can do, then it will not demand the related skills. Furthermore, legislation on a graduate school practicum in Mexico is nonexistent for this field of study.

This series of observations motivated the creation of a practicum program at a graduate level similar in nature to those offered in several U.S. institutions. The idea was to create a three credit hour graduate level course in which, for seventeen weeks, the students would diagnose a problem and provide a solution in an external company.

This idea did face many challenges to get launched: (i) overcoming faculty resistance, (ii) selling the concept to the companies, (iii) setting up time for students to be at the companies, (iv) planning each project and agreeing on the deliverables, and (v) developing the course dynamics. These are discussed next.

Faculty resistance, although surprising, can be attributed to getting people out from their comfort zone. Most of the concerns about the course had to do with not knowing how feasible the practicum projects would be and how this program could be maintained in the long run. The way to overcome this issue was through focusing in the short term, discussing the program as a pilot project where the evaluation of its outcome would determine if it could be considered for the long run. Another source of anxiety had to do with the time these projects would consume at the expense of the student's thesis research project. To this end, it was agreed that the scope of the projects would be assessed before a student was associated to it.

Selling the concept to the companies was a very tiresome process. Indeed, the complete working scheme had to be detailed before contacting them. Because many of the faculty members had peers in the industry, this network was the natural first line of contact as entry points to the companies. The next step entailed a formal letter from the Graduate Studies chair, detailing the practicum course, its scope, what the company would get, and for what it would pay. A formal presentation at the companies that were positively interested ensued (about one out of three contacted were interested). Simply put, it was required that the company paid for the students' transportation and meal expenses one day of the week as a minimum, provided the students with working space, and designated a point of contact. During the meeting, the responsible of the course negotiated the deliverables of the project and secured a meeting for progress review on the eighth week of the semester. The graduate program coordinators, who were in charge of scheduling courses, had to agree to leave the Thursdays of each week free for students to spend time at their respective companies.

A key negotiation point with the companies was to get them to provide some time for the students to diagnose the problem and gather data, then have a progress review meeting right in the middle of the semester. This meeting provided the opportunity to reevaluate the scope of the projects and keep them feasible in terms of deliverables in time.

The course dynamics included 1.5 hours in the classroom and at least 2 hours in the company per week. In the classroom, each session was dedicated to review one of the projects thoroughly with discussion and feedback from all the students and the lecturer, as well as 3-minute rapid progress reviews from all of the other projects. The first time the course was offered, there were a total of eight projects, so the sessions did allow for this kind of organization.

Also, the first time the course was offered (under the name Operations Research applications in the industry), out of a class of eleven graduate students, ten of them signed up for it. A total of five companies were able to provide eight projects.

At the end of the semester, a poster session was organized. This poster session helped to showcase the practicum program to students, faculty and all the participants from the industry. Also, from this experience, a consulting contract involving four students and three faculties was achieved. Furthermore, six MS theses were based on the work developed during this course in that particular graduate class. Four participating students were interviewed for jobs at their hosting companies, and two of them received and accepted job offers after graduation.

The practicum course is offered now every other semester to graduate students in at least their third semester of enrollment. Thus far, a total of 30 students in 22 practical cases in 15 companies have participated. Close to two out of three students who have taken the course have been able to relate their MS thesis to this experience. The graduation rate also seems to be higher among students who take the practicum course. Additionally, several papers have resulted from these short projects (Álvarez et. al., 2009; Garcia et.al., 2008; Salazar et. al., 2006; Villarreal et.al., 2009). A particularly important result from this program can be seen in Figure 1, where it is noticeable that starting from the class where the practicum course was introduced (2004), the percentage of students graduating before 2.5 years has increased dramatically.

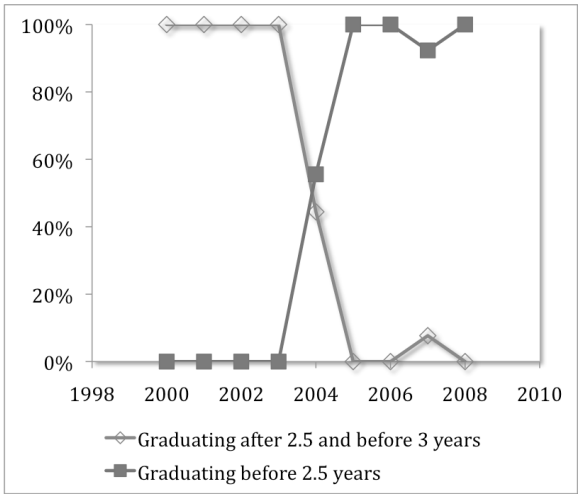

Figure 1. Percentage of students graduating at two different intervals in time organized by class.

As an example of a case study developed under this scheme, one can cite that described by Alvarez et. al. (Álvarez et. al., 2009). A telecommunications company needed to forecast its transmission demand to then decide how much equipment had to be purchased and at which points in the year. These decisions were made at the beginning of every fiscal year for budgeting purposes and involved amounts in the order of millions of dollars. The forecasting part of this project was approached with artificial neural networks (Salazar et.al., 2006)]. However, capacity planning lent itself to an interesting development that turned the telecommunications capacity expansion problem into an inventory problem. At that point, such conversion had not been reported in the literature thus providing a publishable research idea along with a convenient and practical solution that generated a measurable benefit to the host company (Álvarez *et. al*., 2009).

1.2 THE COLOMBIAN CASE

In Colombia, higher education institutions seek to obtain a quality certification issued by the government to comply with decree 1295 issued on 2010, which stipulates that these institutions must demonstrate their relationship with the external sector, that is, their relationship with the community and the productive sector. In addition, law 789 of 2002 chapter 5, provides guidelines for practicum programs in the industry. These guidelines state that students enrolled in the lasts semesters of their bachelors program may get learning contracts of less than two years. The law also states that companies with more than 15 employees are required (except for construction companies) to link practitioners at a rate of 1 apprentice for every 20 workers.

Universities in Colombia also usually have a number of credits equivalent to one course for students to get real working experience as a prerequisite for graduation at undergraduate level. This endeavor usually takes up to six months of practice for students in a company. It is common for the universities to have an office dedicated to match up students with company opportunities.

In the case of one of the largest private Universities in the southwest of the country, these credits take the form of an industrial practice course in which students enroll in their ninth semester (the undergraduate program is intended to last ten semesters). This course is one of the most important in the curriculum. The job undertaken in this course can actually start from the eight semester up to the tenth one, allowing for companies to retain students for professional employment. In fact, courses during the eighth, ninth and tenth semester are scheduled at night to facilitate that the students retain these kinds of jobs. The university's student employment and professional practice office is in charge of initially matching the students and the companies. Project follow-up however, is beyond this office's responsibility, and was not formally pursued until 2009.

In 2009 Industrial Engineering faculties started to provide mentorship to the students and methodological aid to the match-up process. A designated professor would visit the companies to obtain the company's evaluation on the students' performance, as well as to assess how effectively the problem had been solved through the students' technical skills. As result of this work, the program had to look into establishing a more formal process.

In 2010, the Industrial Engineering program saw the need for the creation of rules and standards for the follow-up process to better serve the growing needs of the companies and insure that the working experiences remained of educational value. Such transformation is described next.

1.2.1 FOLLOW-UP PROCESS

In order to make students aware of the importance of the course, the faculty holds a meeting at the beginning of every semester to explain how these work experiences contribute to the learning process and how the students' performance in the companies reflect on the University.

A coordination area was created in the program to accrue the information regarding job offers as well as information about the progress reported for the industrial practice course (each section could have up to ten students). The coordination area is now in charge of managing the students' registration process, matching the available industrial opportunities to the students' profiles, keeping track of each work experience progress, assessing the experience of the participating companies and applying timely corrective measures when company concerns appear.

The faculties in charge of the courses were responsible for providing the student with technical guidance, keeping the coordination area informed about the progress of each project, making sure that the student complied with the university's code of ethics and behavior, making sure that the company treated the student fairly, and reporting a final grade for the student.

With this organization, faculties and students were then engaged in a more coordinated process that involved frequent contact between them and the companies. It also facilitated technical and personal mentorship, project ownership and a more effective troubleshooting process.

From the first experiences, one particular weakness was revealed: students usually lacked the ability to effectively present their ideas and convey technical information. Copy-pasting information from online sources without an insight for its correctness and overall consistency further aggravated this problem. Such problem has already been recognized in the literature (Sporer et.al., 2009). The long-term corrective action included the selection of ten books, one per each of the intended 10 semesters to obtain an undergraduate degree, for the students to read and discuss for credit under the supervision of a faculty.

A series of results are already tangible from this recent liaison effort. An undergraduate thesis relating statistical analysis and efficiency improvement in a brick factory was presented on 2009 and two more theses on the application of value stream characterization and work study were presented in 2010. In addition, the possibility of involving students in early phases of their college studies has already attracted the attention of some companies, providing evidence of a renewed interest in the professional practice projects. This involvement has also opened opportunities for final course projects – usually shorter in length and extent- to be conducted at the companies' premises. As a result, a book about engineering tools that generate value to enterprises is currently in print (Acosta & Anaya, 2011).

Although there is not yet a formal study about the impact of the program described previously, Figure 2 shows the number of students involved in work experiences since the follow-up process was established. The university has gained confidence and momentum in approaching new companies for their involvement. In time, it has also become evident that the companies have gotten more comfortable sharing their needs and providing feedback on the student's performance.

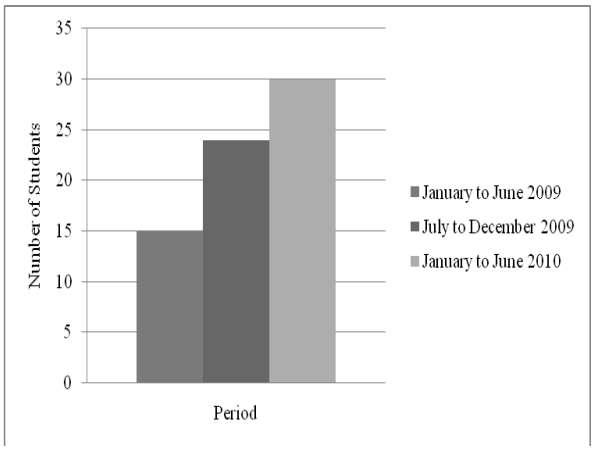

Figure 2. Number of students involve in work experiences.

The Industrial Engineering department has benefited a lot from this effort. The faculty is now highly encouraged to participate in the collaborative projects as mentors and the students see the program as an attractive opportunity to apply their newly acquired skills and to show them to the companies as a marketable value. In fact, it is perceived that the number of job offers to the participating students has increased within the last year.

One particularly important next step is to start charging the companies participating in these projects, if not to make a profit, at least to make each project self-paid. In the long term, starting up consulting activities within the department where faculties and students can participate is one of the central goals.

CONCLUSIONS

Two efforts on starting-up successful liaisons between academia and industry in Latin American countries were described in this manuscript. Several difficulties had to be overcome in terms of organization, resistance, providing a tangible value to the industry, and properly gauging the industry needs in both cases. The benefits of establishing these liaisons, however, are perceived to be large enough to outweigh the shortcomings. The interest of faculty, students and people from the companies generated by these programs in their respective communities is evidence of their feasibility when proper planning, organization and support are put into place. It is essential to nurture these efforts to at least begin to provide examples of effective translation of academic knowledge to profitable value to the industry. Such local examples should prove easier for students to relate to, and hopefully, become a natural step in their professional development. Finally, extracting a key series of actions from these two cases, these authors can recommend that a person interested in developing a similar program in Latin America, (1) takes charge from the beginning of the project, (2) follow a well-crafted plan of execution, (3) start with simple goals aiming for feasibility and break-even points, and (4) be very

persistent both with peers in Academia as well as professionals in the industry. In Latin America, as in any other part of the world, what is seeked is the creation a virtuous circle of problem solving through education.

REFERENCES

Álvarez, C., Özdemir, D., & Cabrera, M. (2009). Capacity planning in a telecommunication network: A case study. International Journal of Industrial Engineering 16 (2), 82-90

Acosta, M., & Anaya, A. (2011). Implementación de herramientas generadoras de valor en las actividades primarias de la cadena de valor. Cali, Valle del Cauca: Editorial Bonaventuriana.

Carvalho, J., & Etzkowitz, H. (2008). New directions in Latin American university-industry-government interactions. International Journal of Technology Management and Sustainable Development 7 (3), 193-204.

Ferrer-Balas, D., Buckland, H., & De Mingo, M. (2009). Explorations on the University's Role in Society for Sustainable Development through a Systems Transition Approach. Case-Study of the Technical University of Catalonia (UPC). Journal of Cleaner Production 17 (12), 1075‑1085.

García, V., Castro, J., Mireles, J., Chacón, O., & Cabrera, M. (2008). Setting the Processing Parameters in Injection Molding through Multiple Criteria Optimization: A Case Study. IEEE Transactions on Systems, Man & Cybernetics, Part C: Applications & Reviews 38 (5), 710-715

Giuliana, E., & Arza, V. (2009). What Drives the Formation of 'Valuable' University-Industry Linkages? Insights from the Wine Industry. Research Policy 38 (6), 906-921.

Gulbrandsen, M., & Smeby, J. (2005). Industry Funding and University Professors Research Performance. Research Policy 34 (6), 932-950.

Hansen, J. & Lehmann, M. (2006). Agents of Change: Universities as Development Hubs. Journal of Cleaner Production 14 (9-11), 820-829.

Laursen, K., & Salter, A. (2004). Searching High and Low: What Types of Firms Use Universities as a Source of Innovation?. Research Policy 33 (8), 1201-1215.

Mathews, J., & Hu, M. (2007). Enhancing the Role of Universities in Building National Innovative Capacity in Asia: The Case of Taiwan. World Development 35 (6), 1005-1020.

Nagy, J., & Robb, A. (2008). Can Universities Be Good Corporate Citizens?. Critical Perspectives on Accounting 19 (8), 1414-1430.

Salazar, M., Moreno, G., & Cabrera, M. (2006). Statistical Characterization and Optimization of Artificial Neural Networks in Time Series Forecasting: The One Period Forecast Case. Computación y Sistemas 10 (1), 69-81

Salter, A., & Martin, B. (2001). The Economic Benefits of Publicly Funded Basic Research: A Critical Review. Research Policy 30 (3), 509-532.

Siegel, D., Waldman, D., Atwater, L., & Link, A. (2003). Commercial Knowledge Transfers from Universities to Firms: Improving the Effectiveness of University–Industry Collaboration. Journal of High Technology Management Research 14 (1), 111-133.

Sporer, N., Brunstein, J., & Kieschke, U. (2009). Improving students' reading comprehension skills: Effects of strategy instruction and reciprocal teaching. Learning and Instruction 19 (3), 272-286.

Thorn, K., & Soo, M. (2006). Latin American Universities and the Third Mission: Trends, Challenges, and Policy Options. World Bank Research, Working Paper 4002.

Villarreal, M., Castro, J., Chacón, O., & Cabrera, M. (2009). Optimization of a Painting Line through Simulation: A Case Study. Industrial Engineering Research Conference (May 30 - June 3, 2009) Miami, Florida

Youtie, J., & Shapira, P. (2008). Building an Innovation Hub: A Case Study of the Transformation of University Roles in Regional Technological and Economic Development. Research Policy 37 (8), 1188–1204.