Industry Sponsored Practical Undergraduate Learning: Two Case Studies from The University of Puerto Rico

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ABSTRACT: *In less than 8 years, an initially modest partnership between the Electrical and Computer Engineering Department (ECE) at the University of Puerto Rico at Mayagüez (UPRM) and Texas Instruments, Inc. (TI), evolved into a well rounded learning program supporting undergraduate and graduate research, curriculum development, laboratory activities, and Coop experience for undergraduate and graduate students with the company for periods of up to eight months. The birth of this collaboration was facilitated by the previous ties created under the umbrella of the Industrial Affiliates Program which, for the last 14 years, has being channelling the sponsorship of a number of internationally renowned companies to support undergraduate research projects. Participating students have acquired further tools to develop their technical background in a professional environment, as well as to improving their communication skills and bolstering their self-confidence. Many students have also found motivation to attend graduate school. Employers have experienced high student retention rates, measured in terms of the number of participants who become full-time employees after graduation. The program also has contributed to raising the quality of education offered at the ECE department by fostering the creation of new, up-to-date courses and attracting donations for the creation of a new laboratory.*

This paper describes the UPRM-TI and the IAP programs, presents statistics quantifying their achievement, and identifies key elements for the implementation of successful industry-sponsored practical learning experiences

1 INTRODUCTION

1.1 The Future of Global Education: Main Issues

Balancing theoretical classroom learning with practical experience is fundamental in Electrical and Computer Engineering Education. During the last 30 years, close collaborative ties between university and Industry have become essential in view of the constant technological changes. Creating programs to bring together and harmonize the needs of Industry and Academia involves the following main issues:

- Students expect an education that will provide them with cutting edge technological experience so that, after graduation, they can take up challenging and well paid jobs, or continue on to higher education [F. Courtney, 2001].
- Industry demands new employees with previous field work experience or at least with specific practical training. Often Companies are under pressure to fulfil their short term needs and emphasize their demand for engineers with specific skills, even if those skills will become obsolete with the next technological wave.
- The University is required to provide high quality multidisciplinary general education together with up to date courses and hands on learning activities related to technological research and development.
- Society needs flexible creative self-learning engineers endowed with ethical and social competence who can make a long-term contribution in spite of technological change [H. Sobol, 1990]. In addition, individual countries are under pressure to excel in world class research and development to maintain their position in the global economy.

1.2 The Academic Setting

The University of Puerto Rico at Mayagüez – with 765 faculty members and almost 15,000 students-- ranks 14th in the U.S. in terms of undergraduate engineering enrolment, 18th in awarded engineering degrees and 3rd in engineering degrees awarded to women, according to the year 2000 survey of the American Society for Engineering Education. It is also the largest Hispanic engineering school in the country.

The student population of the ECE department consists of about 1500 fulltime undergraduates (11% of the campus´ total), 60% of which major in Electrical Engineering. The university boasts a 30% female undergraduate enrolment. The B.S. electrical and computer engineering programs were established in 1928 and 1981 and gained ABET accreditation in 1960 and 1994, respectively. The department also offers a Ph.D. in Computer and Information Science and Master Programs in both electrical and computer engineering.

2 THE MOTHER PROGRAM: INDUSTRIAL AFFILIATE PROGRAM (IAP)

IAP has been running for the last 14 years, insuring a unique and fruitful continuity in the relationship between academia and industry. Among the many benefits of IAP, we would like to emphasize its role as springboard for industry's more significant commitment to education as in the case of the UPRM-TI program presented later in this paper. IAP features include: activities extending beyond pure research chores, students taking on responsibility for their research, and activities running over two semesters in parallel with the regular academic year.

IAP provides funds for approximately 20 undergraduate projects each year. Projects are assigned a budget of up to $3000. Development activities are carried out under the guidance and mentoring of approximately 12 faculty members who work *ad honorem*. Projects are selected based on proposals submitted by faculty and industry. Students are given two months to warm up at their tasks and prepare a poster paper describing their projects. They present these papers during the first meeting. To finalize their participation, the students present their work in front of an audience during the Fall Conference. Thus, besides acquiring some experience in research and development, participation in IAP provides students with skills in public presentation, teamwork, and report writing. More than 500 undergraduate students have participated in IAP. Funds for projects and operational expenses are provided by a group of industry members. See [M. Toledo-Quiñones *et al*, 2003] for a more complete description of the IAP program.

3 THE UPRM-TI PARTNERSHIP

This full-fledged collaborative program, as illustrated in Figure 1, evolved from a modest collaboration initiated in the context of IAP in the fall of 1997. In 1998, a small-scale COOP initiative recruited a few students. These students had been involved in undergraduate research projects in the IAP and had taken an active interest in seeking ways to put into practice many of the basic theoretical knowledge they were acquiring in the classroom.

During the eight months this first group of students spent as TI co-ops, they not only performed at a very high level in their assigned tasks, but also generated the enthusiasm to follow up on their personal research interests. To this end they agreed to complete independent "side projects" jointly mentored by UPRM faculty and TI supervisors that could be presented to the academic community upon their return to UPRM. These side-projects were successful not only for the technical depth gained by the students, but also for their effectiveness in communicating to others the various rewards provided by the coop research experience. These accomplishments triggered closer contacts between the company and the University.

In summer 1998 some of the faculty involved in mentoring the students were invited to an internship at the company as visiting professors. Subsequently, a faculty proposal aiming at supporting and encouraging the participation of students in undergraduate research and COOP programs was funded by the company. As a result, an Analog Electronics emphasis area was formally established in the ECE Department of the UPRM with support from the company. Moreover, the program backs up students interested in pursuing an advanced degree in electronics through research assistantships.

Since the establishment of the program, eight additional groups of students have had the opportunity of participating of the program, most of them with participation in Coop, undergraduate research, and side-projects.

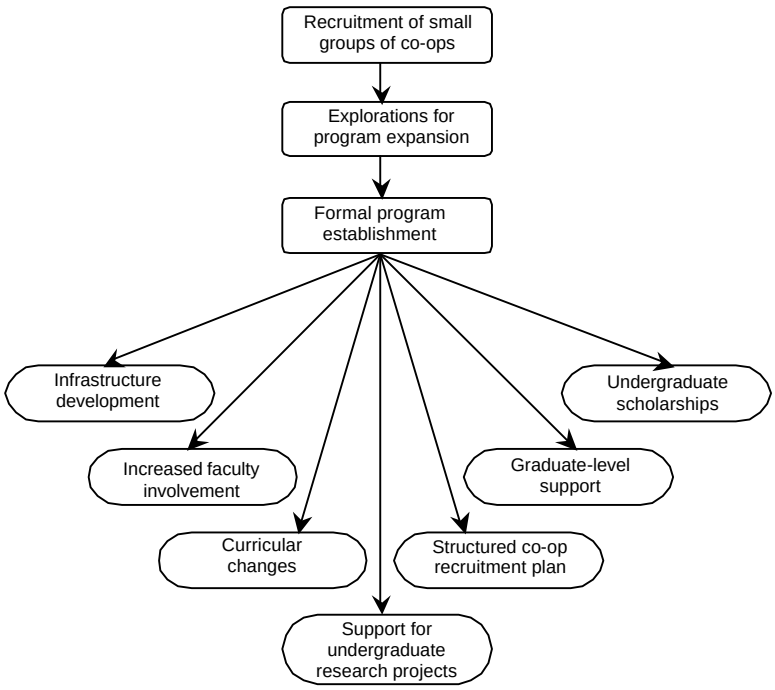

Figure 1- Development of the UPRM-TI partnership.

3.1 Advantages for the students

The programs have contributed to the rise in the quality of education offered at the ECE department not only by blending abstract learning with practical experience but also by boosting student's academic performance, work maturity, and professional insight. The participating students gained tools essential to developing a sound technical background in a professional environment as well as to improving communication skills, self-confidence, and furthering career advancement.

Most of the students who chose to continue with graduate studies after receiving their college degrees, selected a field related to their activities in the program. In their opinion the COOP experience and the related research activities were essential to motivate them towards higher learning.

3.2 Advantages for the University

The ECE curriculum has been strengthened by the inclusion of three new elective classes in the area of analog electronics. Also, the support received for laboratory development has improved the teaching and research infrastructure in the electronics area. Moreover, scholarships funded by the program have attracted more students to participate in undergraduate research projects. Besides helping to develop students' essential skills to succeed in graduate school, this also encourages them to continue and pursue advanced degrees and provides the professors with students to work on their research projects. Third, the professors' summer internships allowed them to keep in touch with industry practice, expanding their pool resources when they return to the classroom.

3.3 Advantages for Industry

From the company's standpoint, the results have also been very encouraging. Since the beginning of the collaboration several dozen students have participated in the program, completing over a dozen different side projects. Although during the last two years the poor shape of the economy forced the company to reduce the number of COOP, the company's support for the UPRM-TI partnership as remained unchanged.

Figure 2 shows the distribution of participants in the stage of development of the program prior to the current economic slowdown. The number of participants was increasing steadily. This is evidenced by the time information indirectly embedded in the chart. Note that the earliest participants of the program are those who already completed their degrees. These students, distributed in two equally sized groups, represent approximately 33% of the total number of participants in the program so far. The students who

just returned from their COOP experience followed the first three groups, while the newcomers at the time of writing this article are currently having their COOP experience. The chart does not include the students who are currently in the phase of undergraduate research prior to the COOP experience, a group similar in size to that doing COOP.

From those students who completed their degrees, 64% chose permanent employment with the sponsoring company, which compares favorably to a University-wide COOP program retention rate below 30%. It also compares favorably with well-established engineering COOP programs at other universities, like for example that of University of Washington, with 48% retention rate. It deserves to be mentioned that these students had multiple, highly competitive job offers from various other companies, denoting the importance of the experience gained through the program as a career builder. Moreover, most of those who have chosen this option still consider a full-time position at the sponsoring company as their first choice after completing their advanced degree.

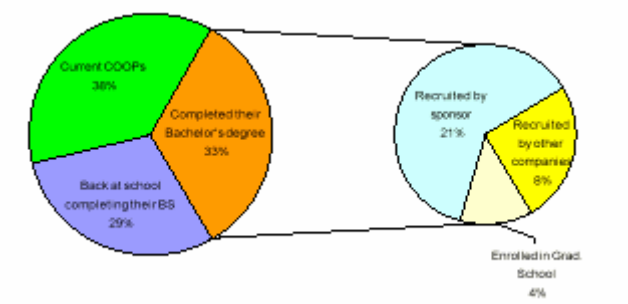

Figure 2- Distribution of participant students.

4 KEY ELEMENTS

Those elements that have played a key role in the developing, maintaining, and making a success of this program are outlined below. The outline order reflects the structure of the program itself, illustrated in Figure 3.

4.1 A solid student general educational background

The importance of interdisciplinary learning, with a strong Liberal Arts basis, for students of engineering is often emphasized [L. Frederic, 2001]. Studies have found that students with a good general background make better human beings and excellent engineers. The need for wise professionals, flexible enough to adapt to a variety of situations in their professional or academic careers is widely felt. Universities are crucial in providing this kind of educational exposure. The UPRM makes an effort in providing engineering students with a well-rounded education in all fields. The university also provides structured programs and the necessary resources to foster novel educational approaches and provide adequate support for faculty to work on curriculum enhancement.

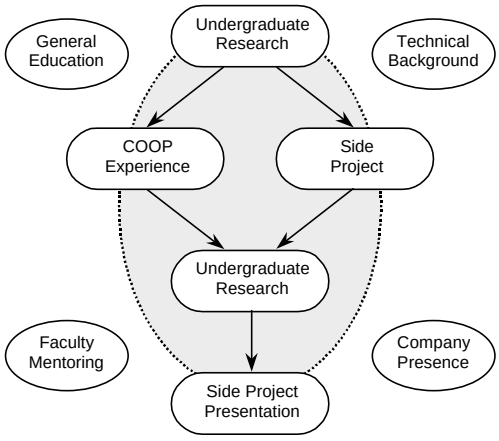

Figure 3- Structure of the enhanced COOP program.

4.2 Strong company commitment and support

The level of company involvement was crucial to the positive outcome. In spite of the geographical distances, IAP sponsors and TI, in particular, maintained a regular presence in the UPRM campus by sending officials to offer seminars and presentations, and to participate in job fairs. Texas Instrument's support for an in-campus laboratory and projects helped to improve the curriculum and showed the student's appreciation for their work. In addition, the company's engineers and staff provided students with good mentoring and support, not only from the technical and professional but from the human point of view.

4.3 Undergraduate research experience and faculty involvement.

By Ggiving students the opportunity of working in research projects prior to their participation in the COOP has proved to be a particularly successful approach. The benefits include program exposure to attract new students, increased self-confidence and academic performance in the students, and the development of skills for performing independent work with minimal supervision. The development of this last skill has proven to be particularly important for the students making a difference in the way they performed. In addition, mentoring faculty members act as role models for the young undergraduates not only at a scientific and technical level but also at the human, social, ethical, and cultural levels. The preliminary undergraduate research has been essential to blend and facilitate the integration of regular college instruction with work experience, theory with practice, and academic culture with corporate culture.

4.4 Development of a side project while at COOP

One of the most innovative aspects of this program has been the involvement of students in what we have called a "side project". A side project is an optional problem selected by the student in coordination with his or her supervisor and an academic advisor, which they work on while in the COOP. This project however, is not part of the student duties as a COOP. Instead, the student develops it as a project of his or her own. Those students who choose a side project have in addition a side project supervisor who in coordination with their faculty advisors follows up their progress. Back at school, the students complete their side project through a special topics course, write a detailed report, and give public presentations about it.

Usually, the chosen problems are not related to proprietary elements or sensitive information pertaining to the company. This allows the students to freely speak about "their projects" among other students and to formally divulge the results in seminars and presentations. Over 90% of the participants have chosen to work on them either individually or as part of a team. Many students are attracted to such projects because they boost their sense of pride for what is often their very first instance of engineering craftsmanship.

Side projects have shown to be very beneficial to the students in multiple ways. While in the COOP, these students have developed a higher level expertise in their area of work than those who did not choose a side project. This has made them look good in the company. It has also helped them to re-focus on their study program by selecting with new wisdom the courses they still need to take to complete their degrees.

4.5 Getting Students interested

Project presentations by those who have already participated in the program are an important factor. On the other side, undergraduate research is offered for credit. On top of that scholarships funded through the program serve as an added incentive. Any interested student can participate in the program. To ensure a proper strength in the students' background in the technical areas supported by the program, three new technical elective courses in analog design and circuit optimization have been introduced to the ECE program. From these courses, each student should take at least one before going to the COOP, and before graduating he or she is expected to have taken at least two of them.

5 CONCLUSIONS

The list of benefits derived on each side of this relationship includes the following.

- Participating students develop their technical background in a professional environment, improving their communication skills, self-confidence and career opportunities.

- Some students have been inspired to attend graduate school in a field related to their research or COOP work after completing their degrees.
- Employers have experienced high student retention rates, measured in terms of the number of participants who become full-time employees after graduation. Moreover, most of those students who have chosen to go to graduate school still consider the sponsoring company as their first option after completing their advanced degree.
- The programs have boosted the number of students participating gaining valuable practical experience in undergraduate research and Coop. This has helped to update academic programs and support research activities.

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