Industry Sponsored Undergraduate Research at UPRM

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ABSTRACT *—A solid collaboration between the Electrical and Computer Engineering Department (ECE) at the University o f Puerto Rico at Mayagüez (UPRM) and Texas Instruments, Inc. (TI) has been developed during the last 8 years. A learning program supporting undergraduate and graduate research, curriculum development, laboratory activities, and Coop experience for undergra duate and graduate students with the company for periods of up to eight months is the result of this collaboration. This relationship has been facilitated by the existence of the Industrial Affiliates Program (IAP), an undergraduate research program that f or the last 14 years has being channelling the sponsorship of a number of internationally renowned companies. By participating in these programs, students have improved their technical background, acquired experience in a professional environment, and impr oved their communication skills. Employers, in the other hand, have experienced a high rate of participants who become full -time employees after graduation. The quality of education offered at the ECE department has been improved by the creation of new, up -to-date courses and from donations that lead to the creation of a new laboratory. This paper describes the UPRM -TI and the IAP programs, provides a summary of some of the projects that have been carried out, presents statistics, and identifies elements fo r the implementation of successful industry -sponsored practical learning experiences .*

Index Terms — *Industry-university collaboration, problem -based learning, and undergraduate research*

INTRODUCTION

During the last 30 years, close collaborative ties between university and industry have become common. Creating programs that successfully bring together and harmonize the needs of students, industry and academia is a difficult task because the needs and expectations of these three sectors can be different. Students expect to gain access to interesting and well paid jobs by completing a modern and up-to-date curriculum. Industry deems previous work experience and practical training to be highly desirable and even necessary. Society needs self-learning and creative engineers who understand the ethical and social implications of their work and that can make a long-term contribution in spite of technological change [1]. To satisfy these needs, many electrical engineering programs find increasingly necessary to complement a solid general classroom education with hands-on learning activities related to technological research and development, and have created special programs and courses to do so.

This article describes two industry-university collaboration programs administered by the Electrical and Computer Engineering Department of the University of Puerto Rico at Mayagüez. The university, which according to the American Society for Engineering Education ranks [2] 13th in the U.S. in terms of undergraduate engineering enrolment, 19th in terms of awarded engineering degrees and 2nd in engineering degrees awarded to women, is also the largest Hispanic engineering school in the country.

In the remaining of this document a short description of the programs is followed by a summary of some of the projects that participating students have carried out. Statistics and elements that have contributed to the success of the programs are also presented.

INDUSTRIAL AFFILIATE PROGRAM

The IAP was created in 1989 to provide students with the opportunity of participating in undergraduate research projects. The organizational aspects of IAP were described in detailed in [3]. The program provides funds for approximately 20 undergraduate two-semester projects each year. Projects are assigned a budget of up to $3000. Development activities are

supervised by approximately 12 faculty members who do this work *ad honorem* . Proposals are submitted by faculty and are prepared either independently or in collaboration with industry. A committee composed of 6 faculty members is in charge of reviewing the proposals and approving the projects.

One of the objectives of IAP is to enhance the student's research experiences to include public presentations by requiring participation in two public meetings. About two months after beginning their work in January, students are required to prepare and present a poster paper describing their projects. Later in the year, during the fall a larger conference is celebrated in which students present their work in front of an audience.

Funds for projects and operational expenses are provided by a group of industry members. During the present year 8 companies contribute $5000 each to support the program. This money is used to fund the projects, pay for the cost of associated the two meetings, and for administrative expenses.

Assistance Technology for Handicap and Impaired People
Antenna Redesign and Re-localization for Lightning Network Detection
Comparative study of applications with mixed components
Design of a High load power amplifier
Rain Attenuation Retrieval Using Surface Reference Techniques
Development of a Knowledge Management System
Elastically Replicated Information Systems
Design & dev. of a max. power tracking scheme for Photovoltaic Devices
Power factor improvement in a switching power supply
Micro Wireless Sensor for Bearing Health Monitoring
Optimal Loc. of Dist. Generation Units on Radial Dist. Feeders
Active sub-woofer
New Methods for Calculating Transmission Loss Coefficients
A Low-Cost Digital Phase-sensitive Amplifier based on the TMS430
Field Performance Study of Bluetooth in Presence of 802.11b/g
Digital Class Attendance
RF Powered Telemetry Sensor Interface using the MSP430
Development of Multi-Hole Wind Sensor
A Web-Based Wireless Controller for the Telescope at the Physics Department
OLED Display Cooling System
Semi-Autonomous Robot for Small League Soccer Game

TABLE 1
LIST OF IAP PROJECTS FOR YEAR 2004

Table 1 provides a list of the 21 projects that are being carried out this year. It can be observed that the projects deal with a wide range of topics that span over several electrical and computer engineering areas, including: electrical power systems, instrumentation, electronics, robotics, information systems, and communications. An idea of the typical complexity of the student's tasks can be obtained from the following three summaries:

- **IRDA Stack Using the MSP430**

  IRDA is a standard defined by the IRDA consortium (**I**nfra**R**ed **D**ata **A**ssociation). It specifies a way to wirelessly transfer data via infrared radiation. The IRDA specifications include standards for both the physical devices and the protocols they use to communicate with each other. The IRDA standards have arisen from the need to connect various mobile devices together. The IRDA standard is divided into a variety of hardware and software protocols. For an explanation of these protocols and a brief tutorial on IRDA technology please visit ACTiSYS' website at http://www.actisys.com/article.html

  This project consists in the implementation an IRDA stack on Texas Instrument's MSP430 microcontroller. The initial goal is to have the team create a portable, low-power MSP430 driven device that is able to discover, negotiate, and communicate via the IRDA protocol with a PDA, PC, etc. The IRDA stack should be *completely*

implemented within the MSP430 using efficient code and the least amount of power and resources. It would also be expected that the project be clearly demonstrated at the physical layer.

- **New Methods for Calculating Transmission Loss Coefficients– A Comparative Study**
  The calculation of transmission losses in a power system through B-coefficients or similar loss formulations is well known. The use of B-coefficients for loss formulation is still popular among electric utilities for Economic Dispatch purposes. However, it is also known that these coefficients are not truly constant, but vary with system operating conditions. In an attempt to overcome some of the deficiencies associated with classical B-coefficients, new loss formulation approaches have been proposed in the literature. This work aims at performing a comparative study between several recently proposed methods for calculating transmission loss coefficients. These comparisons will be carried out using standard IEEE test systems. Results will be evaluated in terms of their robustness and accuracy.
- **Development of Multi-Hole Wind Sensor and Associated Electronic Interface**
  There is a great need for a sensor that is capable of determining the speed and direction of wind with high spatial resolution, and yet is low-cost and maintenance-free. Preliminary simulations show that developing an innovative wind sensor, capable of measuring the speed and direction of wind, is promising and doable. This project consists in the development of a proof-of-concept prototype of this new sensor, which is based on the multi-hole principle and can be constructed using simple micro-fabrication techniques. Specifically, the project aims at conducting conceptual design, simulation of various wind sensor shapes, construction of a simplified device and development of the associated electronic interface. A simple experiment setup will be developed to characterize the prototype and to prove the concept.

THE UPRM-TI PARTNERSHIP

This collaborative program was initiated in the context of IAP in the fall of 1997 and has developed successfully to its present status, to include support for the curriculum, faculty support, infrastructure, and professional development workshops to cover non-technical skills such as communication, project management, leadership skills, and so on[3]. An analog electronics emphasis area was formally established in the ECE Department of the UPRM with support from the company, and a number of research assistantships were created. To date, over thirty students have participated of the program at TI, and many more have obtained research internships at other universities associated with the company. Most of the students going to TI have participated in IAP undergraduate research projects before working as Coops at the company, and performed research projects of their own interest (we call them *side projects*) while working at the company as coops.

The program has provided several advantages to UPRM's ECE community, such as:

- improved in the quality of the ECE curriculum by fomenting the creation of new curses;
- boosting student's academic performance, work maturity, and professional insight;
- providing students with a sound technical background;
- improving the students communication skills, self-confidence, and furthering career advancement;
- supporting the creation of an advanced electronics laboratory;
- providing scholarships;
- helping faculty to keep in touch with industry practice by participating in summer internships at TI.

One of the key elements for the success of this collaboration has been the IAP undergraduate research experience. Giving students the opportunity of working in research projects prior to their participation in the COOP has the following benefits:

- improved program exposure to attract new students;
- increased self-confidence and academic performance in many of the students, and
- help develop skills for performing independent work with minimal supervision.

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.

Another key element has been the involvement of students in what we call a "side project" - an optional problem selected by the student in coordination with his or her supervisor and an academic advisor, on which they work while in the COOP. This project, not being part of the student duties as a COOP, has been developed by the students on their own. Back at school, many students have completed their side projects by participating in a special topics course, and have given a public presentation about it. The following are examples of three side projects that were realized:

- **High Speed High Performance Amplifier**: An operational amplifier with high speed and performance characteristics was designed. TI technology was used in the characterization and fabrication, and the results were very satisfactory. The experience gained with this design was instrumental in later professional achievements.
- **Modified Algorithms for using the Eagle Tester in Production Tests**: This project modified testing algorithms for using relatively low cost testers for activities in product testing, produced programs that reduced the required testing time by a factor of four, and provided resources to process the tests in parallel. An overall improvement of the testing process by a factor of eight resulted from the project.

- **Design of an Adjustable Low-voltage, Low-dropout Regulator:** A low-voltage, low-dropout (LDO) regulator with two different output voltages (1V or 1.8V) was designed. The proposed LDO was designed using 0.35µm CMOS technology and is able to drive a load of up to 50mA with a maximum dropout voltage of only 200mV. A low quiescent current (at no load) of approximately 23mA, makes this a low-power design**.**

Participation in side projects have shown to be very beneficial to the students by fostering the development of a higher-level expertise in their area of work, improving the perception that company employees and supervisors have of the students, and helping the student focus their study program for the coursework that they still need to take to complete their degrees. From the company's point of view the results have also been very positive, since In particular,

- Many of the very good students that have participated in the program later become regular company employees.
- Productivity has been impressive in the students that became fulltime employees.
- Generation of published results [4, 5] has given exposure to the company as supporter of education, as well as improved opportunities to industry mentors in internal promotion.

The productivity achieved in short time by former students who have become employees has been impressive. Former students working in testing and product engineering have developed methods to boost and improve testing time and algorithms. Some of them are now product engineers who have become worldwide team leaders in less than two years. Similarly, former students with IAP and side project experience now working in design have shown increased productivity as compared with peers in the same period of time. In less than three years they have generated several patents, some of which are mentioned in reference [6], produced several pending patents and more patents application under review, as well as commercial products such as high-speed ultra-low distortion and ultra-low noise amplifiers [7]. These results are important benefits for the company. Similar performance has been observed in students who did not join the company, but went to other corporations.

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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