AN UNDERGRADUATE RESEARCH PROGRAM SUPPORTED BY INDUSTRY

Manuel Toledo-Quiñones, José G. Colom-Ustáriz
University of Puerto Rico
Mayagüez, Puerto Rico

Abstract

Practical problem solving, together with a firm theoretical background and a broad education, play a very important role in engineering education. The Industrial Affiliates Program (IAP) is an interesting model of active learning that addresses today's pressing needs of blending theory with practice, education with work, academic scientific rigor with industry's fast pace.

The program, administered by the Electrical and Computer Engineering Department (ECE) at the University of Puerto Rico at Mayagüez (UPRM), complements a five year curriculum by providing undergraduate students with the opportunity to participate in a research project. Each year, over 20 projects, dealing with a diverse set of electrical and computer engineering topics, receive sponsorship from internationally-recognized companies.

This article provides an overview of IAP and describes student projects. Also presented are statistics about student and faculty participation. The benefits to students, industry, university, and faculty provided by the program are discussed. Possible extensions to the program are summarized.

The Department

The University of Puerto Rico at Mayagüez, the third largest campus of the state-owned university system of Puerto Rico, homes the daily activities of about 765 faculty and almost 15,000 students. According to the American Society for Engineering Education's (ASEE) 2000 edition of *Profiles of Engineering and Engineering Technology Colleges* UPRM ranks 14th in the U.S. in terms of undergraduate engineering enrollment, 18th in awarded engineering degrees and 3rd in engineering degrees awarded to women. It is also the largest Hispanic engineering schools in the country, and has been fully accredited by the Middle State Association of Schools and Colleges since 1946.

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. Around 30% of the undergraduate students are females. 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 administers master programs to about 80 graduate students. A summary of the department's student population and graduation statistics is shown in figures 1, 2 and 3.

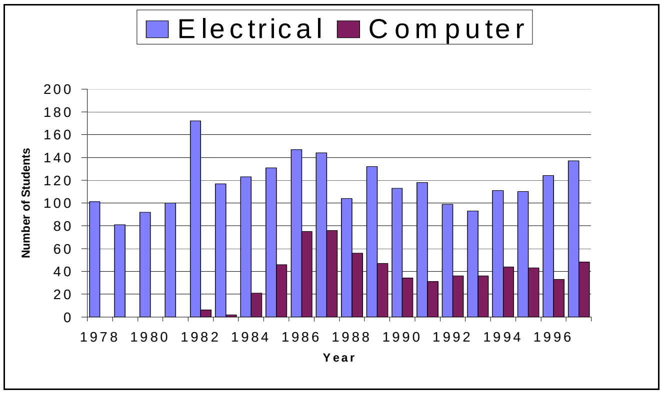

Figure 1: ECE Student graduation statistics

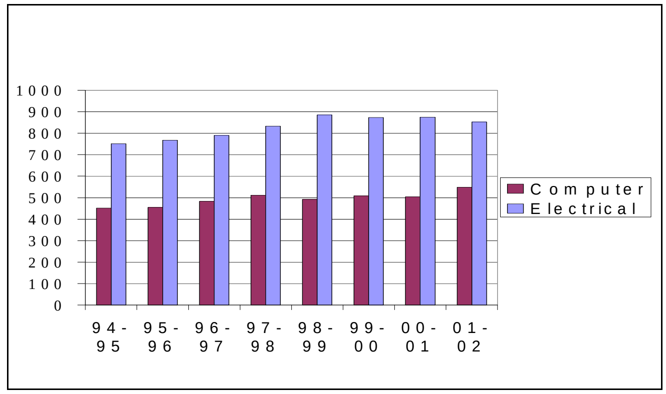

Figure 2: Student population by department

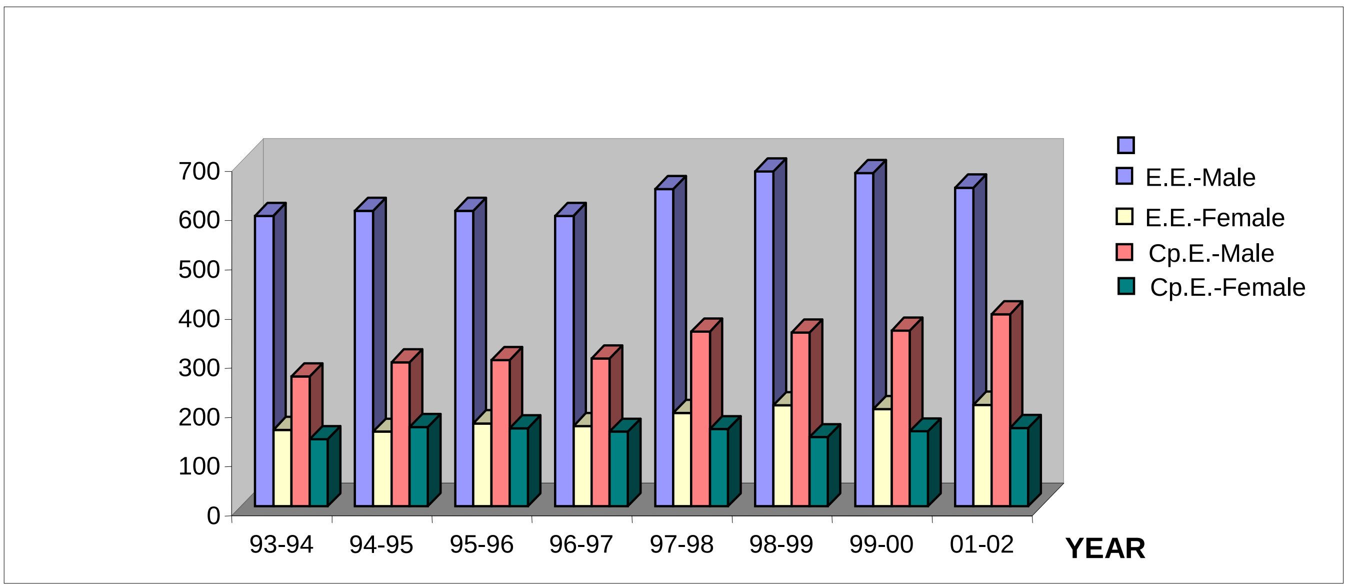

Figure 3: ECE student population by gender

Overview of the IAP

There exist many programs similar to IAP[3,4,5]. However, our program distinguishes itself for offering activities extending beyond pure research, assigning full responsibility to the students for their research work, and for running activities over two semesters in parallel with the regular academic year. The activity schedule is summarized in table 1. Industry representatives, students and faculty attend the two largest meetings that take place in spring (early October) and fall (late April). In these meetings the students that are performing research give a poster presentation (October) and a public talk (April).

Table 1: IAP schedule

ACTIVITY	APPROXIMATE DATE
Request for Proposals	August
Project Selection	Early September
Poster Presentation Seminar	Mid September
Poster Presentation and Spring Meeting	Early October
Research	Late September to Mid April
Public Presentation Seminar	Mid April
Research Presentation in IAP Conference	Late April
Report writing	Mid April to Mid May

IAP provides funds for approximately 20 undergraduate projects every year. Each project is assigned a budget of up to $3000. Development activities are carried out under the guidance and mentoring of about 12 faculty members who work *ad honorem*. Students can receive credit for their work or receive a stipend. Projects are selected based on proposals submitted in September by faculty and industry. In October a meeting is held and students prepare a poster paper describing their projects. In April, a conference in which the students present their work in front of an audience is celebrated. Thus, besides giving students the opportunity of acquiring some experience in research and development, participation in IAP provides them 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. Figure 4 summarizes the participation in IAP.

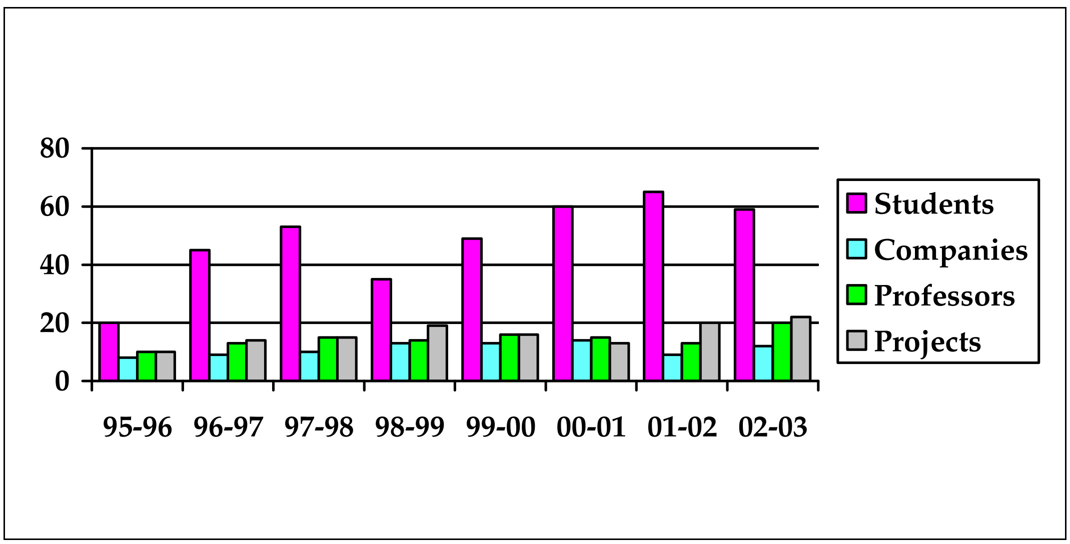

Figure 4: Participation in the IAP program from 1995 to 2002.

The program is run by a coordinator and 3 assistants. A six member faculty committee is in charge of selecting the proposals that will be supported, and provides general help during the year. An advisory board, composed of representatives from industry, meets twice a year to provide strategic advice. Students receive either credit or a stipend for their work. Professors administer each individual project and volunteer the time they spend advising the students.

The Students' Experience

In a survey performed last year, students were asked to qualify their experience in the program by assigning a weight to the following six statements and questions:

1. IAP helped me understand theoretical concepts and/or other material discussed in class.
2. IAP helped me improve my communication skills (presentations, poster, and oral communication).
3. IAP helped me apply the theoretical concepts to the IAP projects.
4. I am now more interested in working with IAP member companies compared to non-members companies.
5. IAP helped me increase my interest in Graduate School
6. Would you recommend other students to participate in IAP?

Students where asked to provide an answer between 1 and 5 to each question, as shown in figure 5. The great majority of the responses are positive.

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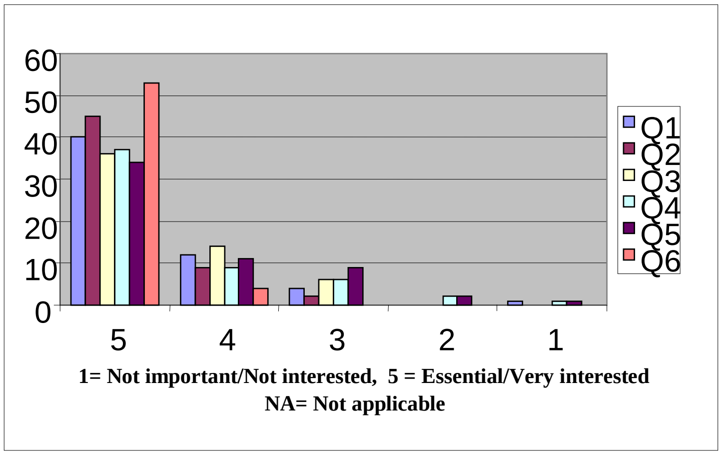

Figure 5 Survey's results.

Also included in the survey were several additional questions. The overly positive response (56-yes, 1-NA) obtained to the question "Would you recommend your future employer to participate in IAP?" suggests that students place a high value on their IAP experience. When asked about their positive and negative experiences during their projects, participants reply:

Best experiences:

- Share with students, faculty, and IAP member in a professional way.
- Work in real problem.
- Apply concept learned in class.
- Improve communication skills, and present in front of audience.
- Team work.
- Present work to others.

Worse experiences:

- Fear and stress before presentations.
- Everything has to be done at the last moment.

- Deadline related stress.
- Coordinate research and class schedule.
- The presentation week happened to be the worst week of the year.
- Lack of communication with other students and advisors.
- When will the materials arrive?
- Presenting with bad partners.

Some answers describe situations may come-up in the professional practice. Thus, IAP experience might help students to deal with the situation –perhaps prevent it- later on.

IAP Projects

The IAP projects span a wide range of electrical and computer engineering topics. Two or more students work in each project. Table 3 shows the project titles for this year.

Table 2: IAP projects for 2002-2003

Tren Urbano Passenger Information System (TU-PIS)
Acoustic Characterization of Impermeable Membranes: Hearing Aid Applications
Distributed Generation in Electric Power Systems
Development of learning Management System
Analog Hardware Implementation for Morphological Neural Networks
Bringing real-time data processing to the Atmospheric Phenomena Laboratory's lightning location network
Probabilities of Lightning Strikes as a Function of Structure Elevation
Efficiency of a Solar Hydrogen Scaled System
Data Service Composition in Database Middleware Systems
Understanding the effect of Signal to Clutter ratio, clutter characteristics, and noise factors on the performance of a Synthetic aperture Radar automatic Target Recognition Imaging System
DCT-Based Lossy Compression of Grayscale Still Images
A Genetic Algorithm To Discover Linear Codes with Large Min. Distance
The design of a 1.8V LVDS Receiver (Second Part)
Cirrus Ice Crystal Simulation using IDL and DDSCat; Microwave Remote Sensing of the Atmosphere for Weather Applications
X-Band Weather Radar: Location Survey and Design
Precipitation Measurement
Digital Signal Processing Project Development and Implementation: Active Digital Speaker Correction
Modeling and Performance Evaluation of Distributed System
Wireless Strain Sensor Development

The scope of student's work can be better understood from the following summaries, which are based on a selection from the 2001-2002 presentations.

<u>Soccer Robot:</u> A group of students developed two teams of autonomous robots to play *Soccer Robot.* The robots played soccer against an opposing team while receiving information through several sensors and processing instructions in a microcontroller. The students put together a

wireless communication system that linked the microcontroller to a personal computer that measured the robot's position using a global camera and sent control commands to the microcontroller. This project helped students to become familiar with subjects like computer vision, embedded system programming, wireless communications and robotics.

Digital Watermarking Implementation: Watermarking can be used to overcome problems of illegal copying, falsification, copyright protection, and ownership identification. This project explored the watermarking of still grayscale images. The technique consisted in embedding an imperceptible key-based pattern within the image to be watermarked. Detection of the watermark in a processed copy of the image was shown to be possible and provided a way to verify its authenticity. The implemented algorithm was robust to several common distortions and operations, such as jpeg compression, low-pass filtering and cropping. Students developed and tested the algorithms using MATLAB© and then ported the code to a Digital Signal Processor. The project helped students learn about digital signal processing, embedded system development, image processing, enhancement and compression, multimedia and watermarking.

Wireless Multi-carrier Acoustic Transmission of Digital Video: Wireless technology is an important aspect of multimedia communications. This project explored innovations in data and video transmission of digital video by successfully developing a system capable of transmitting digital video images wirelessly through a distance of 12.5 meters. An algorithm that implemented RGB and YCC Image coding was used to compress the data while preserving an acceptable image quality.

Industry Participation

The strong participation of industry in engineering education is very important to stimulate the updating of student's learning, essential in our world of constant technological change. The IAP program provides faculty and company representatives with the opportunity to establish a closer relationship. Sponsoring companies can propose projects in subjects of their interest. A faculty member interested in the subject supervises the students so that they acquire specific skills of interest to a particular company. Participation in an industry-proposed project strengthens ties between faculty and company, and also gives greater visibility to the participating students. Often this leads to a summer COOP position, and usually increases the probability of future full-time employment.

Table 3: Sponsoring companies of the IAP for 2002-2003

Texas Instruments, Inc.	Eastman Kodak Company
Verizon Corporation	EMC Corporation
Hewlett Packard, Inc	Raytheon Company
Sun Microsystems	Motorola
Mitre	Boeing
IBM	Microsoft

Industrial participation in IAP has increased steadily, as shown in figure 4. A total of 12 companies (see table 3) are participating in the program during the 2002-2003 academic year. Support for the program is obtained from a membership fee of $5000 per year paid by each participating company. A total of 22 projects are being supported during the 2002-2003 academic year with grants of up to $3000.

Overall Benefits

The IAP program is a catalytic force that promotes closer ties with the production world and strengthens industry-university collaboration. Extensions to the basic IAP format are not uncommon and have generated improvement of laboratory facilities through company donated equipment, joint faculty-industry proposal writing, faculty summer internships, and the enrichment of the university curriculum through the creation of new courses. In one specific instance a company follows up the IAP experience with COOP employment that normally takes place during the summer and semester following participation in IAP. Students develop a research project while working at the company, and continue working on it for extra credit on after returning to the university. Satisfactory performance in this exercise often leads to an employment offer.

Conclusion

The IAP program shows how collaboration between industry and university results in original and innovative educational methods that prepare students for the ever new challenges of the future. Students test their capacity to work independently and interdependently[2] at solving a real problem and presenting their solutions to the public. In the process they develop crucial skills including critical and creative thinking, teamwork, communication, organizational, and experimental skills. This is of great benefit to the production world and to society in general.

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Biographical Information

Manuel Toledo-Quiñones finished his BS the Electrical Engineering Department at UPRM in 1979, his MS in Applied Physics at the University of Massachusetts in 1989, and his Ph.D. in the Electrical, Computer and Systems Engineering Department at Boston University in 1995. He joined the University of Puerto Rico in 1998, where he has been an assistant professor at the Electrical and Computer Engineering Department. He is currently involved in projects in the areas of wireless micro-sensors, watermarking of medical digital images, automatic detection of vehicle license plates, modeling and simulation of Chemical Vapor Deposition, and vehicle tracking using GPS. He also coordinates the IAP program.

JOSE G. COLOM USTARIZ
Jose is currently an Associate Professor at the University of Puerto Rico Mayaguez. He has a Ph.D. in Electrical Engineering from Penn State University and an MSEE from UMASS at Amherst. His research interests are microwave circuits, microwave remote sensing, and numerical methods for electromagnetics. He is currently the coordinator of the COOP program at the ECE Department and member of IAP committee. He teaches courses in the area of Applied Electromagnetics and basic circuit analysis.