

## **Bring Realism Into the Classroom Through Your Consulting**

**Richard E. Pfile**  
**Associate Professor of Electrical Engineering Technology**  
**William R. Conrad**  
**Professor of Electrical Engineering Technology**

Indiana University-Purdue University at IUPUI  
Indianapolis, Indiana

### **Abstract**

The half-life of an engineering degree is said by some to be approximately five years. In a teaching career that may span twenty or thirty years, consulting and applied research are necessary to keep up with the many changes that take place in technology. Skills learned from projects can be applied as case studies in the classroom or as exercises in the laboratory. Several models for successful applied research centers are presented.

### **Introduction**

The mission of a technology program is to produce graduates who are ready to be productive in the workforce when they graduate. Besides teaching general principles and concepts, it is imperative that students are introduced to technology used by industry. This is fundamental to the mission of technology.

Although industrial experience is a precondition for technology faculty to be hired, in many fields the half-life of an engineer is five years. Faculty need to be continually exposed to the best practices of industry. Just as their counterparts in industry, the faculty need to be lifelong learners<sup>1</sup>. One of the best ways for a faculty member to maintain technical currency is to become involved in industrial projects as a consultant or in a school center that conducts applied research. Besides keeping faculty members' technical skills up-to-date, involvement in applied research and consulting renders other benefits such as: (1) providing real-world case studies to be used in classrooms and laboratories, (2) strengthening relationships between the school and industry which can boost corporate donations to the school and enhance student placement, (3) educating employers about technology education, (4) generating income and prestige for the school, and (5) educating professors about employment opportunities available for students in the local area. While the benefits of involvement in applied research and consulting are multifaceted, the most important benefit is the confidence and credibility it allows instructors to

bring into the classroom.

## **Consulting Examples and Teaching**

Over the years the authors' have been involved in many consulting activities that have kept their technical skills current and provided case studies that are used in the classroom. One consulting job was writing the control software for an industrial gantry type robot. The control computer was interfaced to incremental position encoders, dc motor servo systems, and hydraulic control systems on the robot. As a direct result of the experience, a set of laboratories was developed for an advanced microprocessor course. Students write a series of programs which are then combined into a single large program that controls a robot arm. Many concepts from the consulting experience such as homing a robot arm, pulse width modulation control, feedback control, and using multiple interrupts from incremental encoders to track arm position and velocity were directly incorporated into the laboratories. The laboratories are very popular with students and the technology taught has applications in many different areas of industrial control. While presenting the material, stories are related to students about the consulting project; the development process, design tradeoffs made, component selection and the overall development and support process. This livens up the class and provides a change-of-pace in the classroom. It also gives students an appreciation of the environment in the workplace.

Another project involved writing control software for a welding robot using a real-time operating system. The project provided a good background in the benefits of using real-time operating systems in complex systems<sup>2</sup>. After this experience, a laboratory using a real-time operating system was put in the advanced microprocessor course. Although the limited laboratory does not show the full capabilities and benefits of using a real-time operating system, the project is used in the classroom as a case study of an application that lends itself well to a real-time operating system.

Another consulting job involved designing hardware and writing software for an automatic air conditioner charging system. The system was required to be low cost but have the most sophisticated controls of any such device on the market. To keep costs low, an eight-bit microprocessor with minimal onboard memory was selected. This dictated programming the device in assembly language. Software routines used in that project such as algorithms for number conversions, table lookup techniques and using an interrupt generated fixed time base for control calculations, provide outstanding application examples for students in an introductory microprocessor course. The applications are discussed in the class when the algorithms are presented. Knowing that the material taught was used in an actual industrial project, provides real motivation to students in the classroom, particularly global or visual learners<sup>3</sup>.

The first author also learned Visual C++ Windows programming through experience gained from a consulting project. Industry has lost nearly all interest in the development of new DOS-BASED programs. Many technology programs are teaching students to write DOS-BASED programs and need to update the advanced programming courses. Writing Windows C++ programs is a challenge. By some estimates, it takes approximately six months of full-time

programming to be productive<sup>4</sup>. Visual C++ has approximately two hundred different classes with each class having ten to fifty functions. In addition, the structure of the program is quite complex and non-intuitive. When faced with teaching a C++ Windows course for the first time, the author lacked confidence and struggled answering difficult questions from students. The Windows interface is so diverse and complex, learning the fine points is difficult. After writing a substantial Windows program for a firm, many finer points of the language were learned for the first time. This experience increased the author's confidence in teaching the language, and provided an in-depth knowledge of the language that could not have been achieved by just teaching it in the classroom. The experience also made the author appreciate the degree to which industry has shifted emphasis from DOS-BASED applications to Windows.

Consulting as an expert witness testimony for industrial accident cases has provided case studies for the power courses. These case studies are excellent when teaching guarding, grounding, and safety practices.

By working on various projects, the application and value of PC-BASED systems in automation and the value of microcontroller-based systems for embedded control applications have been appreciated. Over the years, the authors have also been involved in small projects that have used operational amplifiers, instrumentation amplifiers, SCRs, opto isolators, and other devices. The knowledge learned has been useful in helping students with senior design projects.

Students are interested in the job environment and relating stories about consulting jobs helps motivate them in the class. When faculty become involved in consulting projects, they should ask about the overall project development and talk to people about the day-to-day development of the project. They should find out about production, field tests, manufacturing and sales. The entire product life cycle from project conception to field support for the product can be related to classes to help students see the big picture in project development. It also creates an awareness of the spectrum of job opportunities available for graduates.

## **Applied Research**

The IUPUI School of Engineering and Technology also awards internal grants to work on research projects. These grants are awarded by a school committee and can be used to buy equipment or pay faculty summer stipends. The authors have taken advantage of one of these grants to design a system to detect the boring angle for underground trenching equipment. The system uses a level sensor with a mounted LASER that shoots down a tube to a target, where a miniature television detector is located. Electronics was designed to determine the position on the television camera raster where the LASER beam strikes the target and thus the position of the head-end of the boring tube. Providing internal seed grants is a great way to get faculty members involved in applied research.

The author are currently working on another applied research project to design a low cost and efficient controller for electric vehicles. This project will use a newly released Texas Instruments digital signal processing (DSP) chip with an integrated ac motor vector control unit<sup>5</sup>.

We expect this work to provide an example of a unique application of a DSP chip for the digital signal processing course and the machinery course.

## **Promoting Applied Research and Consulting Activity**

As competition has increased for government funding, schools have taken a greater interest in forming links and obtaining funding from industry. Programs and centers have been created to establish connections with industry. Such programs should provide proper financial and career incentives for faculty to become involved in the activity, flexible contract arrangements with rapid approval processes, and reasonable overhead rates that provide a financial return to the professor's department and school.

Working with industry (especially small companies) requires more flexibility in the contract arrangements than is typical with government contracts. In meetings with representatives from industry, it was made clear that contracts need to be negotiated and approved quickly, and work on the project needs to start promptly. Many projects cannot wait for summer or until the next semester when a course buyout can take place. An ability to pay faculty supplemental income for short term assignments is essential.

### **Model Applied Research Centers**

The Indiana University School of Business has the **Center for Entrepreneurship & Innovation** that is a nearly ideal model. Professors who work for the Center are paid a supplemental salary above their regular salary for short-term work assignments. They are not restricted to summer pay or arranging course release during a semester.

The IU program overhead rate is very reasonable and is shared between the faculty member's department, school, and the consulting center. The low overhead rate, allows a faculty member's rates to be competitive, and the payments to the department and school provide an incentive to the department to allow faculty members to participate. Any contracts less than \$30,000 are handled directly by the center and can be quickly negotiated. The center generated approximately \$600,000 in business during the past year. Publicity is generated by distributing brochures.

At Purdue University in West Lafayette Indiana, a program called **Centers for Excellence** has been started to promote the school of technology in the community. Groups of businessmen are brought to the campus to see presentations by faculty members on various technical topics and are told about the school of technology's capabilities. The goal of the center is to increase community awareness of the capabilities of the school, and obtain applied research projects and contracts for corporate training. The program has been particularly successful providing corporate training. Currently, the center has more projects available than faculty can handle. The director of the center, a retired executive with considerable clout in the business

community, has many industrial connections that have been paramount to the success of the center. The program has some difficulty operating within the rigid confines of the contracting procedures at Purdue University. An inability to pay faculty supplemental compensation for work has dampened faculty participation. Approximately \$500,000 in revenues was received in the past year.

Another program at Purdue University at West Lafayette is called the **Technical Assistance Program**. This program receives state funding and is designed to provide small businesses free short term (approximately eight hours total) technical assistance. Faculty members serve as technical consultants and a one-quarter release time is typically funded for every faculty member who takes part in the program. Small problems can sometimes be handled within the eight-hour project limit. For other problems, the company may be steered to someone who can provide longer term assistance or the project may be picked up as a student project.

Another model is at the University of Hartford within the college of engineering. They have established the **Engineering Applications Center**. This organization's goal is to provide cost-effective help for applied research and development. The center has several laboratories and institutes specializing in manufacturing, acoustics and vibrations, energy management, and biomechanics. Companies interested in working with the center are encouraged to become Center Affiliates. For an annual fee of \$23,000 companies receive up to three hundred hours of faculty time and up to one hundred hours of undergraduate time. The Center collaborates on the investigation of issues and problems specific to the Affiliate, conducts database searches to identify new information that is of value to them, and notifies them of new developments in its business or industry.

IUPUI has an organization called **AdvanceTek** that is a nonprofit corporation closely aligned with the Purdue School of Engineering and Technology in Indianapolis. It has a mission to act as a catalyst for advancing the applications of engineering and technology through public and private consortia to enhance the competitiveness of American industry. Industry representatives approached the Purdue School of Engineering and Technology at IUPUI and proposed that an organization be established to represent their collaborative interests and compete for technology development funds. After three years AdvanceTek has five active consortia administering projects valued at approximately fifty million dollars. Although AdvanceTek is independent from the school, some of its staff are university employees and the organization rents space from the school. AdvanceTek contracts with faculty for sponsored research involving students and faculty. Most of the funds received by AdvanceTek are sent to private industry, but the school received approximately \$150,000 for project work from the organization in 1997 and established corporate contacts that have led to other research projects. Many of the AdvanceTek projects are applied research in nature.

## Conclusion

Consulting and applied research can benefit the school, students, faculty, and of course industry. A formal program to promote applied research and consulting in the school can be

started with minimal effort and can pay handsome dividends.

1. Black, Kent M., "An Industry View of Engineering Education", Journal of Engineering Education, January 1994, pp. 26-28.
2. Landman, Ronald G., "Selecting a Real-Time Operating System", Embedded Systems Programming, April 1996, pp. 79-88.
3. Montgomery, Susan M., "Addressing Diverse Learning Styles in a Large Classroom", ASEE Annual Conference Proceedings, June 1995, pp 344-349.
4. Kruglinski, David J., "Inside Visual C++", Microsoft Press, 1996.
5. "TMS320C24x DSP Controllers", Texas Instruments, 1997, pp. 2-66 - 2-74.

RICHARD E. PFILE is an Associate Professor of Electrical Engineering Technology at Indiana University Purdue University Indianapolis. He received his B.S. from the University of Louisville and his M.Eng. from the University of Michigan. He teaches courses in digital electronics, microprocessor systems, and computer networks. He has 12 years of teaching experience and eight years of industrial experience, including three years as a systems engineer.

WILLIAM CONRAD received his MEng degree in general engineering from The Pennsylvania State University in 1968. He has been a member of the Indiana University Purdue University Indianapolis Electrical Engineering Technology faculty since 1991. Before joining IUPUI, he was associated with the John Deere Foundry East Moline, serving as a senior engineer in the Plant Engineering Department. He has also taught in the Electrical Engineering Technology Department at Michigan Technological University, Houghton, MI. He is a registered professional engineer.