A MODEL FOR ESTABLISHING INTERNATIONAL INDUSTRIAL / ACADEMIC RELATIONSHIPS

Rick Homkes[1] and Zdzislaw Filus [2]

Abstract *— The authors of this paper present a model for establishing cooperative arrangements with international industry partners. These arrangements could include the establishment of student cooperative education and internship programmes, faculty internship programmes, continuing education for working engineers, industrial incubators, sponsored research, and new courses to fit industry and regional development needs. The two authors met at a meeting held at Delphi Automotive Systems Technical Centre Krakow. One of the authors is a Purdue University (USA) professor who is also a member of the Engineering Training Council (ETC) for Delphi Delco. The other author is a professor at the Silesian University of Technology (Poland). This Polish University has just been selected as a university partner by the Technical Centre Krakow. The paper will specifically address the development of two new courses, one in Poland and the other in the USA, which are focused towards an industry need while maintaining academic quality. The sharing of materials between the authors will help both universities in developing like courses.*

Index Terms — Academic / Industry Relationships, Course Development.

INTRODUCTION

It is the responsibility of a faculty member to handle three different tasks in his or her career. These are to teach, to research, and to serve. The combination of the teaching, research, and service roles is the requirement for academic promotion at most USA universities. The new president of Purdue University uses the somewhat synonymous terms “learning, discovery, and engagement.” These terms come from the Kellogg Commission on the Future of State and Land-Grant Universities in the US.[1] Part of the engagement aspect of the Commission’s recommendation has to do with partnerships with local industry for regional development.

Poland has had a much more turbulent time for its industry and academia in the last two decades. The change from a communist to market economic system has put tremendous strains on the economy and society. One area where this restructuring has taken place is the relationship between a university and the industries in its region. Like the US, universities are now investigating how they can become ”engaged” with local industries, both for academic survival and regional economic growth.

A POLISH EXAMPLE

One author’s place of work is the Institute of Electronics, a part of the Faculty of Automatic Control, Electronics and Computer Science. This faculty is one of the 11 faculties of the Silesian University of Technology.[2] The university, located in Gliwice, southern Poland, is one of the largest Polish technical universities, having over 25,000 students at present.

In communist Poland most of the country’s heavy industry was located in the surrounding region of Upper Silesia. The last decade has brought about dramatic changes. The traditional region’s industries have been on the decline and new industries, including high technology industries, are being developed. This is one reason why the number of students entering the faculty has roughly tripled since the early 1990s and the total number of students studying electronic engineering now exceeds 1,300.

In particular, the region has become the main center of Poland’s automotive industry. Fiat’s small-size cars have been manufactured in Tychy, less than 50km from Gliwice, and Bielsko since the early 1970s. At the end of the last decade GM Opel located a manufacturing plant in Gliwice, just a few kilometers from the university, and Isuzu started mass production of CI engines in Tychy. Many world-known vehicle component manufacturers, including Delphi Automotive Systems, have also established their branches in the area.

To respond to the needs of this industry the university has entered into cooperation with some of these manufacturers, starting from a cooperation agreement signed with Fiat in 1997. The Institute of Electronics has been active in this field from the very beginning, starting research into 42V/14V switching converters for the 42V systems. Recently first contacts have been made with the newly established Delphi Technical Center in Krakow. It is hoped that these contacts will result in new cooperative agreements in this sponsored research.

Another part of these activities was to develop a course of lectures on Automotive Electronics. It has been offered

[1] Rick Homkes, Purdue University, P.O. Box 9003, Kokomo, IN USA 46904 homkesrl@purdue.edu
[2] Zdzisław Filus, Silesian University of Technology, Akademicka 16, 44-100, Gliwice, Poland filus@boss.iele.polsl.gliwice.pl

as an optional lecture to ninth-semester students since the academic year 1998/1999 and the number of students attending the course was between 40 and 60 each year. An overview lecture was also given for general public, which was basically meant to attract secondary school students to the faculty.

The core material for the course has been based on *Automotive Electronics Handbook*, edited by Ronald K. Jurgen (McGraw-Hill 1995), *Automobile Electronics* by Eric Chowanietz (Newnes 1995) and Philips data sheets of *Semiconductors for In-car Electronics* (1996). When the course was run for the first time, the students were asked to submit written reports on various aspects of automotive electronics, based on their studies of journal articles and Internet searches. Almost thirty papers were delivered and some of them turned out to be sources of further valuable information.

The course consists of 15 two-hour lectures and its contents are as follows:

- **Introduction.** First applications of electronic circuits to cars. Current trends in automotive electronics.
- **Sensors.** Pressure, linear and angle position, flow, temperature, linear and rotational speed and acceleration, engine torque sensors. Exhaust gas oxygen sensors. Engine knock sensors.
- **Electrical systems.** Multiplex wiring systems. Controller Area Network (CAN). Alternators, rectifiers and voltage regulators. 42V systems.
- **Automotive microcontrollers.** Overview of the major automotive control systems. Specific features of automotive microcontrollers.
- **Engine control systems.** Combustion process in the spark-ignition (SI) engine. Exhaust emission control strategies. Ignition systems. Fuel delivery systems. Lean-burn engine control.
- **Braking and traction control systems.** Operation and basic components of ABS (braking) and ASR (traction) systems.
- **Electronic transmission control.** Operation and control of semi-automatic and automatic transmissions. Electronically controlled continuously variable transmissions.
- **Electronic control of other chassis systems.** Suspension control. Power assisted steering. Four-wheel steering.
- **Electronic switches.** Application of power MOSFETs to switching of resistive and inductive loads on cars. Protection circuits.
- **Body electronic circuits.** Instrumentation. Trip computers. Vehicle condition monitoring. Passenger safety systems. Climate control systems. Antitheft systems.
- **Navigation systems.** Dead reckoning. Global Positioning Systems (GPS).

Over the last three years about 150 students who attended the course have acquired a basic understanding of how various sensors and electronic circuits and systems are used to improve the performance of modern cars. Some of them successfully completed MSc theses dealing with trip computers, CAN applications, etc. A few were distinguished with prizes for the best MSc theses in the area of automotive engineering, which are awarded by Fiat Auto Poland each year.

As for future plans, efforts are made to acquire the appropriate equipment for laboratory work. In two years' time the lectures may also be given in English as two years ago the faculty started the studies that are conducted in English.

AN AMERICAN EXAMPLE

The other author's place of work is the Computer Technology (CPT) department of the School of Technology (SOT) of Purdue University.[3] Purdue University is a relatively large university of over 36,000 students with a main campus in West Lafayette, Indiana, USA, along with SOT outreach sites located in several industrial cities within Indiana, including Kokomo. The university was founded as a "land grant" institution for the advancement of the "agriculture and mechanical arts."[4] As part of this mission, there are distinct and separate Schools of Engineering and a School of Technology (or Applied Engineering). While both would emphasize the mission of teaching and learning, it would be fair to say that the Schools of Engineering are more focused on research and discovery while the School of Technology is more focused on service and engagement. There are approximately 6,000 students in the departments (faculties) within the SOT.

Like Silesia, Indiana is home to many automotive industries. These include a Caterpillar engine plant in Lafayette, a Subaru Automotive assembly plant in Lafayette, the Daimler Chrysler automatic transmission plants in Kokomo, and the world headquarters of Delphi Delco Automotive Systems in Kokomo. Because of this close proximity, there have been and currently are many cooperative agreements between these companies and Purdue University.

A problem that is now receiving great attention in Indiana is the "brain drain" to other states. Indiana has always been known for agricultural and manufacturing, but has had some problems with the advancement of knowledge industries. This is highlighted by one ranking showing Indiana as 47 / 50 states in percentage of people with a BS degree or higher[5] and much discussion about the gain or loss of high tech jobs. It has thus become even more important to work with the industries in the region to help develop the new economy.

One response to this regional need and SOT mission was the Software Skill Enhancement Program (SSEP) developed by one of the author's while on summer holiday from his teaching duties. The SSEP was used by Delphi Delco Electronics (DDE) to reskill redundant electrical and mechanical engineers into the software engineering competency in one semester of intensive coursework.[6] One of the courses identified as needed by these reskilling engineers was Automotive Electronics. However, since no supplier of the course was available in the short timeframe required for program initiation, the course was developed and delivered internally by the DDE Corporate Training department. It used as lecturers Purdue University professors and subject matter experts from the various professional competencies and product lines within DDE. The course used as a text *Understanding Automotive Electronics* by William Ribbons of Michigan State University.

A second course needed by the SSEP was a course in real-time high-level programming. Using a course in C language programming that was already taught, the author incorporated a number of additional topics or themes to specialize the course for embedded product or manufacturing test coding. The course has a prerequisite of a previous high-level programming course and meets for 30 one-hour lectures and 30 one-hour laboratories. The additional topics or themes include:

- **Rigorous coding standards.** The use of rigorous coding standards is enforced throughout the course. This is not just simply requiring indentation and variable names that reflect the variable's use, but also includes standards for naming registers using the microprocessor register name and bit name (e.g. the Motorola HC11 SPI control register would be referred to as SPCR and would use the bit mask SPE_M for SPI System Enable).
- **Programming tradeoffs.** Constant discussion of the tradeoffs in programming that must be considered when coding for embedded systems. These include program size versus throughput, ROM versus RAM use, program readability and maintainability versus conciseness.
- **Fixed-point math.** Program exercises or assignments may include a requirement that no floating-point variables be used. Instead, fixed-point variables using integers and a virtual radix point are used to represent engineering values.
- **Variable classes and scope**. Attention is paid to the ramifications of different storage classes and the scope of variables used in a multi-file, multi-programmer environment for product code.
- **Real-time programming**. Assignments use real-time responses to simulated sensor activity and a real-time loop that has a specific loop time requirement.
- **Software layering**. Use of modular top-down development so that upper algorithm layers can use virtual sensors and actuators without consideration of the hardware drivers and actual physical implementation.
- **Software engineering principles**. Principles of software engineering that include process and quality control. This includes a short discussion of the Software Engineering Institute's Capability Maturity Model[7], a model similar to the TickIT[8] model used in some European countries.

The course has been evolving since its first offering in the 1996 – 97 academic year, and received a new course number in 1999. The course is now taken by many working engineers wishing a better understanding of embedded and manufacturing test programming along with regular students in the Electrical Engineering Technology and Computer Technology plans of study. Over 90 students have enrolled in the course in the last six semesters and it has become a required course in an Embedded Controller Certificate and a Computer Engineering Technology degree.

A third course developed later as part of the SSEP was a software engineering course devoted mainly to product and process issues. Notable about this course is that it has been ported from an outreach site and will soon be offered on the main campus of Purdue University.

CONCLUSION

The two courses described above came into being because the two authors wished to become engaged with the industries in their region. Impetus for this engagement was to provide a better education for their students, better educated employees for the local corporations, and a growing economy. Now that the two professors know each other, sharing can take place regarding their common interests. Information about the Silesian University of Technology's course on Automotive Electronics has already been sent to a Purdue professor who is developing a similar course for first delivery next year. Likewise, information on coding standards, common software process, fixed-point math, and other software engineering topics has been provided for distribution to the Technical Centre Krakow and will be provided to interested Polish partners. These steps, though small in themselves, can help in the development of our regional economies.

REFERENCES

[1] The Engaged Institution: Profiles and Data. (1999, February). Washington, DC: National Association of State Universities and

Land-Grant Colleges. Retrieved May 28, 2001 from the World Wide Web: http://www.nasulgc.org/Kellogg/kellogg.htm

[2] http://www.polsl.gliwice.pl/english.html

[3] http://www.tech.purdue.edu/

[4] http://www.higher-ed.org/resources/morrill_acts.htm

[5] Statistical Abstract of the United States: 2000. Washington, DC: U.S. Census Bureau. Retrieved May 28, 2001 from the World Wide Web: http://www.census.gov/prod/2001pubs/statab/sec04.pdf

[6] Homkes, R. Discovering Mechatronics: A reskilling program for working engineers. In 1st Asia-Pacific Forum on Engineering and Technology Education Proceedings. Melbourne, Victoria, Australia: UNESCO International Centre for Engineering Education, 1997, p. 131-134. ISBN 0 7326 1271 3.

[7] http://www.sei.cmu.edu/cmm/cmm.html

[8] http://www.tickit.org/