Collaboration with Industries in Education and Research

Keshav S. Varde
University of Michigan-Dearborn, Dearborn, USA, varde@umich.edu

Abstract

Most of the engineering graduates in the U.S. seek full-time employment upon their graduation from engineering schools. They do so with very little or no experience in the practice of engineering. Although large corporations have in-house training programs for their new recruits this is not the case with many small or medium-size companies. Even in large corporations, periodic shifting of technical responsibilities could create vacuum in the individual's knowledge base which could lead to inefficient project operation and management. Likewise, engineering colleges have been recruiting most of their faculty with strong research base and interests. These individuals have little exposure to engineering tasks that are carried out in industry, core competencies required to accomplish these tasks and the manner they are practiced in industrial settings.

The College of Engineering and Computer Science at the University of Michigan, having recognized some of these issues couple of decades ago, have addressed some of the problems through various approaches including (a) Strengthening the existing undergraduate co-operative education program (b) Offering co-op program to industrial clients outside the state – at national level (c) Collaborating with several industries to offer specialized courses to their employees (d) Offering short courses to industrial clients in emerging technical areas (e) Developing core competencies in specialized areas of importance to industry (f) Working with industry to develop teaching material by integrating theory and industry practice (g) Faculty doing research on problems of interest to industrial clients and funded by the clients (h) Undergraduate and graduate capstone projects sponsored by industry (i) Access to select industry partners to use college's facilities (j) Offering programs to industry via College's Virtual Learning Tool.

This paper describes some of the activities currently being continued between the industry and the institution and the extent of their success. It also reflects on the impact on engineering programs, students' learning, and faculty development that has played a vital role in the success of the college. This is particularly important to the mission of the College of Engineering and Computer Science as it is located in the midst of world renowned automotive industry that plays an important role in the economic growth of the U.S.

1. Introduction

The University of Michigan-Dearborn (UM-D), a campus of the University of Michigan, was started over fifty years ago through a grant from the Ford Motor Company to provide technical and business talents to the automotive industry and its large base of suppliers. It was started as an upper class institution offering undergraduate degrees in selected engineering and business management disciplines. Over the years, the campus outgrew its initial intent and is now a full-fledged campus offering undergraduate and graduate levels degrees in wide range of disciplines. The College of Engineering and Computer Science (CECS) at UM-D offers undergraduate programs in eight disciplines, master's level programs in eleven areas and Ph.D. programs in two select areas with interdisciplinary focus. The College is located in the midst of highly industrialized community made up of large automotive companies and their tier 1 and 2 suppliers, a modest IT industry serving the needs of automotive, consumer, and business

industry, and several power and alternate energy companies that cater to the growing energy demands of the region.

Over the last 20+ years the College of Engineering has developed strong ties with the local industry in many facets that contribute to the educational goals of the institution, the programs it offers and the students it serves at all levels. They also open up opportunities for the faculty and the industry to participate in collaborative research and development activities of mutual interests. To serve the needs of the industry as well as to provide opportunities to our faculty and students the College established a Center for Engineering Education and Practice (CEEP) and the Institute for Advanced Vehicle Systems (IAVS). The goal of the Institute is to harness the faculty's expertise in automotive vehicle systems along with experimental facilities to develop collaborative activities with automotive industry and its suppliers.

There have been many publications on projects and research conducted by educational institutions in collaborations with industry. Many of these are of specific nature in that the university or its faculty collaborates with industry on specific research and development projects or on a specific patent [1,2]. Others have involved collaboration on the development of pharmaceutical products or medical instrumentation or transfer of knowledge between the two entities [3,4]. This paper is somewhat different in that it describes several collaborative activities that the College currently participates with several industrial organizations to promote education, research and development, and developing technical talents with partial financial support from industry. The paper is divided into three major areas: collaboration in education, collaboration in research, and collaboration in recruiting and retaining engineering undergraduates through financial aid from industry.

2. Collaboration in Education

Over the last two decades there have been many reports on the preparedness of U.S. high school graduates to enter science, engineering and mathematics (SEM) disciplines. This has, to some extent, is reflected in the number of undergraduate pursuing engineering degrees in U.S. colleges and universities. Table 1 shows the number of undergraduates who were enrolled in BS or BSE programs in engineering in the U.S. between 2003 and 2007 and the percent of engineering majors of total undergraduate enrollment [5]. This issue has come to the forefront as global competitiveness in technical arena has increased significantly in the last 8-10 years. Concerns have been raised that without U.S. technical competitiveness the standard of living and the quality of life for its citizens would decline [6,7].

Table 1
Undergraduate Enrollment in Undergraduate BS/BSE Programs

Year	2003	2004	2005	2006	2007
All (in 1000)	14,666	14,974	15,157	15,379	15,800
Engineering (in 1000)	421.8	419.3	409.3	405.5	399.4
% Engineering	2.87	2.8	2.7	2.64	2.52

The trend has alarmed several corporations in the U.S. and they have actively tried to address the problem at some level. CECS has been an active member in partnering with corporations to alleviate some of these problems.

2.1 On-site Undergraduate Program

Because of its reputation and proximity CECS was invited to offer on-site undergraduate program in mechanical engineering to employees of the Ford Motor Co. and its suppliers. It is designed for the technical employees who have had post-high school classes at community colleges or other post-baccalaureate institutions and who desire to upgrade their technical knowledge and skills. The program is identical to the on-campus program except that a limited

number of classes are offered at Ford every semester depending on demand and the level of participants. The cost of the program is borne by the individual's employer. CECS arranges special on-site advising to these cohorts which helps them in selecting appropriate path for success. Most of the participants take 4 to 5 classes each year thereby requiring 6 to 8 years to complete their degree program. Over the last 16 years of the program's existence it has averaged about 40 students per year.

2.2 Custom-Designed Courses

CECS has been offering custom-designed, no-credit classes to several customers in the local geographical area. Most of these classes are at the post-baccalaureate level covering a wide array of topics ranging from project design and management, signal processing, internet security, data mining, power electronics, hybrid vehicle, fuel systems, battery energy storage, etc. The classes meet on select days depending on customers' requirements and faculty availability; the total contact time varies anywhere from 10 to 40 hours. CECS has worked with over 15 major corporations and suppliers in offering the custom-designed courses.

2.3 Collaboration in In-House Programs

Several major corporations have in-house programs to develop core competency and expertise amongst their employees in key areas of their business. But the companies may lack adequate expertise and up-to-date know-how in key strategic subject areas of interest. Over the years CECS has developed good relationship with major corporations and has collaborated with them to meet this challenging task. In collaboration with the company's technical personnel several members of the CECS faculty, including the author of this paper, have developed course material to meet the needs of the industry. The material is of proprietary nature primarily for use by participants of that company. The author developed and offered classes to over 400 engineers over a span of about 10 years to a major automotive client.

Table 2
Co-op Program Participation

Program	No of Participants	Annual Compensation
Computer Science	30	~ $265,000
Electrical & Computer Engineering	72	~ $697,000
Industrial & Manufacturing Engineering	6	~ $54,000
Mechanical Engineering	51	~ $481,000

2.4 Co-operative Education

The co-operative education program (co-op) was a degree requirement for all engineering disciplines when the campus was started over 50 years ago. However, due to demand, the co-op program is now voluntary. Even then, it is a highly successful program. The CECS co-op office works very closely with over 80 local and national companies to meet needs of the companies in specific disciplines. Participation in the program requires the students to work and gain experience in their major field for at least two semesters, with alternating on-campus and off-campus enrollment. It is an upper-level program requiring participants to have met certain subject depth requirements in their major field of study. During co-op assignments the company compensates co-op students which help to defray partial cost of their education. The students are required to enroll in a co-op course while on assignment and submit a report to the activities during their co-op semester. Table 2 shows the average number of students participating annually in the program over the last 5 years. On average, the co-op participants receive an annual compensation of about $1.5 M which helps in the form of financial aid.

2.5 Design and Development Experience

CECS participates in industry sponsored design and development activities designed to provide experience to undergraduate and graduate students. Some of these activities are cost-shared

by the College while others are totally supported in industry. This provides an opportunity to the sponsor to evaluate students as future employees without financial commitment of resources. The student participants are selected by the project director on advice from faculty. Table 3 shows some of the projects undertaken in the last ten years, number of student and faculty participants and funding from industry and government sources.

Table 3
Design and Development Projects

Project	No of undergrads & grads	No of faculty	Funding
Low Mass Vehicle Design	8 and 8	5	$250,000
Hybrid Vehicle Design	5 and 10	3	$90,000
Model T	8 and 4	4	$100,000
Vehicle for Fuel Economy	5 and 0	2	$20,000
SAE Formula Car and Mini Baja	10 and 2	1	$25,000

2.6 Graduate Certificate Programs

For practicing graduate engineers who desire to expand their knowledge and expertise in technical areas of interest, the College developed graduate certificate programs in key areas of interest. The certificate program requires participants to complete four courses in the concentration areas which otherwise would not be possible in a typical graduate degree program. The certificate program is particularly attractive to mature engineers who have been in the workplace for several years and who wish to upgrade their skills in emerging discipline that might impact their work assignment or career. The number of certificate programs offered varies depending on the demand in technical areas of interest to industrial clients. Typically about 6 to 8 programs are offered each year with a total of about 12 graduate engineers participating in the programs.

3. Research and Development Collaboration

The College has implemented several paths for research and development collaboration with industry on problems of mutual interest to faculty and the College. In addition to the conventional path whereby the industry collaborates with one or a group of faculty on specific research project, The College's Center for Engineering Education and Practice (CEEP) leverages faculty's expertise, College's facilities and its graduate and undergraduate student resources to bridge the needs of small and medium size companies in many disciplines. These industrial clients may not have the resources to conduct research and development projects that are essential to advance their products and market share.

CEEP and IAVS caters to three types of activities: (a) Research funding passed through CEEP to promote research and development activities in the College that are unrelated to any specific project but of general interest to clients (b) Direct sponsored research and development activities with a faculty or a group of faculty in collaboration with industrial clients (c) Faculty industry research internship.

3.1 Research and Development through CEEP

The industry research funds channeled though CEEP provides seed funding to individual faculty, generally younger faculty or faculty who wish to change their research focus, to initiate projects that are part of the College's thrust areas. Funding is provided for one or two years with the expectation that the faculty seek sponsored research and development funding from federal, state or corporate sources. One of the other requirements is that at least some component of the projects supported by CEEP trickle down into educational arena. This may involve developing a new course or a module in an existing course or a student project in an existing course. The intent is to expose the students to contemporary technical issues of interest. Over

the last eighteen years of CEEP existence the Center has sponsored over 50 projects averaging about $40,000 per project.

3.2 Collaborative R&D Industry Projects

This type of collaboration develops directly between the individual faculty or a group of faculty and the industry on a specific research or development project of mutual interest. The starting contact point between the two groups is generally the Director of CEEP or the Director of IAVS or the faculty himself. Generally, this is a long term endeavor requiring detailed investigation of direct interest to the sponsoring organization. Given the nature of the institution, contract administration and related legal issues the sort of projects that are suited are those that have a longer timeline and not of urgent nature, as shown in Figure 1.

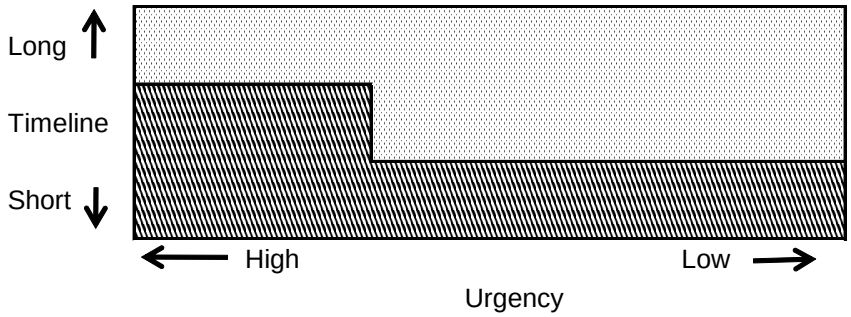

Figure 1. Urgency-time map for CECS-Industry Projects

These types of collaborative activities have provided various side benefits to the College and the sponsoring organization. The sponsors get opportunities to evaluate student assistants for potential future employment with the company. Many of the research assistants who worked on the projects have been hired by the sponsoring organizations thereby providing them with ready personnel talent requiring very little or no training. This has also led to long-term relationship between the College and the sponsors and opportunities for co-op student placements. Over the last ten years there has been an average of 8 to 10 collaborative research projects per year between the faculty and industry with an annual budget of over half-million dollars.

3.3 Faculty Research Internship

This opportunity is provided to younger faculty members to get them acclimatized to industrial research because of their research expertise. Generally, this opportunity is available in summer when the needs for educational activities in the College are low. The arrangements are done through CEEP or IAVS depending on the clients' needs and expertise. This arrangement fits well with the industry where the need for an expert is for a short term. In such a case the organization does not have to commit to a long term employment and is a better arrangement than having a consultant. In the past, the College has had as many as three members of its faculty on industrial research internships.

4. Collaboration in Student Retention and Graduation

As stated in the introduction there have been concerns at the state and national levels that the U.S. does not produce enough engineering graduates to meet the needs of the country. On average the U.S. produces about 70,000 graduates with bachelor's degrees in various engineering disciplines. One of the problems is the lack of sufficient preparation of high school graduates to meet the stringent math and science expectations of engineering students in engineering programs. National projects have been implemented to address the problem but it may take several more years to assess the success of the projects. CECS is also addressing

this issue at several fronts, including research opportunities to undergraduates to relate math and science to engineering problems in laboratories [8,9]. The other problem has to do with the cost of college education in general, and more so of engineering education. As a result, many of the engineering students seek part-time employment which adversely impacts their academic performance. Indirectly, this affects their retention rate and hence adverse impact on graduation. CECS has worked with several industrial organizations (and individuals) to assist in improving recruitment and retention of engineering students.

To achieve this goal CECS has set up named scholarships to freshman and transfers admitted into engineering. Several corporations have provided one-time funds or endowment to fund scholarships. The program has been in effect for about five years and there strong indications that it has helped in improving retention of students in engineering. Table 4 shows the annual amount of corporate scholarships offered to engineering and computer science students.

Table 4
Undergraduate Scholarships Offered by CECS

Corporate Scholarship	Majors	Restrictions	Amount/year
Ford	Any	Restricted	$15,000
Chrysler	Any	Restricted	$20,000
DTE	ME, EE	Restricted	$15,000
General Dynamics	Any	Unrestricted	$10,000
Brick/Other	Any	Unrestricted	$8,000

In addition to these, CECS offers about $260,000/year of endowed scholarships to undergraduates. But this does not constitute industry collaboration and hence not discussed in details. The scholarship program has helped well deserving students to complete their education without heavy financial burden after their graduation. It also represents a well designed plan for industry collaborators to help produce a steady pipeline of domestic engineering graduates.

5. Conclusions

This paper shows the extent of collaboration of the College of Engineering and Computer Science with industry. These activities span over a wide area ranging from education and special courses and program designed to serve the needs of industry to research and development projects to recruitment and retention of domestic students in engineering. The College has been recognized for its close ties with industry and for serving the needs of technical community in Michigan.

References

1. Kim, K. Y., “Turbomachinery Research through Collaboration between University and Industry’, Paper presented at the Asian Aerospace Conference, March 8-10, 2011.
2. Reichman, J. H.,” University-Industry Collaboration – the United States Experience”, Paper presented at the WIPO Conference, June 23, 2005.
3. Van, Z. A., Amadi-Echenlu, J., and Bothman, T. J. D., “Nine Drivers of Knowledge Transfer between Universities and Industry R & D Partners in South Africa”, South African J. of Inf. Management, Vol. 9, 1, 2007.
4. S’Jeggers, R., “A New Faculty Collaboration between Academia and Industry”, Session 3, Conference on the Role of EIT in the Education Landscape, Leuven, Dec 2-3, 2010.
5. National Science Board, “A Report on Science and Engineering Indicators”, Volumes I and II, 2008.

6. Galama T. and Hosek, J., “A Report on U. S. Competitiveness in Science and Technology, Rand Publication”, Washington DC, August 2009.
7. National Science Foundation, “A Report on Worrisome Trends show Eroding U.S. Competitive Advantage in World Science and Engineering Environment”, Washington, DC, January 2010.
8. Varde, K. S., “Energy and Engine Research through Undergraduate Research Program”, Proc. ASEE Annual Conf and Expo, Session 3433, Portland, OR, June 12-15, 2005.
9. Varde, K. S. and Tsui, L., “Development and Implementation of a Structured Outreach Program in IT for Middle and High School Student”, Proc. Of ASEE/AaeE 4th Global Colloquium, Sydney, Australia, Cluster B12, Sept 26-29, 2005.