Industrial Research and the Academic Connection at a Regional University

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Abstract-During the past decade, many industrial research laboratories have become in-house contract providers of technical services to company divisions. Lab emphasis has shifted from long-term strategic projects to immediate tactical problems. Decreasing budgets and staffing in industrial laboratories have had a number of impacts, not the least of which is the potential for industrial-university cooperation. The industrial-academic partnership provides a mechanism in which both parties can achieve significant benefits. Development of university-industrial cooperation is a planned event in which a number of elements are essential. These elements include the existence of a faculty-industrial network, a university business attitude, and an up-front commitment to success by both partners. To realize the benefits of their association, however, both industry and academia must expend the effort and commitment necessary to make the relationship happen.
Keywords: industry, research, regional university

Introduction

Changes in the structure of both industry and academia during the past decade have resulted in a different approach to funded research by both partners. Industrial changes during this period have included an emphasis on quality control, the use of closer product tolerances, and an emphasis on programmable manufacturing systems. Academic changes have included diminished state funding or changes in the funding formula, program specialization, and increased emphasis on economic development.

One result of the changes above noted has been an increased emphasis on externally funded research and contracts at regional universities. Such work is viewed by university administrators as a means of both supporting economic development and addressing state funding shortfalls. At the same time, industry is well aware of university involvement in product development, and as a potential source of expertise that can be applied to industrial operations and problems.

Regional universities with engineering or engineering technology programs have faculty with expertise to contribute to the technical solutions of interest to industry. The extent to which such efforts are successful, however, depends on a whole mix of issues that significantly impact the industry-academic relationship. The purpose of this paper is to address a number of these issues by posing the following questions:

(1) How does a regional university develop an industrial research/consulting relationship?
(2) What infrastructure must be in place to facilitate industrial research and consulting? and
(3) How can a long-term relationship between industry and the university be maintained?

Previous Work

A summary of the current nature of industrial research is provided by de Vries who describes three historic patterns of interaction between the industrial laboratory and the parent company [de Vries, 2]. The first type of interaction described is that of the total lab-factory integration typical of the early 1900s. The second is that of basic research intended to lead to breakthrough technology. The third type of interaction is described by de Vries as

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the current industrial emphasis on contract research. In summarizing this evolution, de Vries states that

> we see that the research labs no longer yield many dramatic breakthrough innovations, but numerous smaller contributions to product development. The lab serves as a continuous source of know-how in a variety of quite different areas.

Engelken discusses the subject of engineering research at predominantly undergraduate institutions [Engelken, 3]. Engelken describes the university as an "agent of transfer for academic wealth," and he points out that university research involves not only quantifiable expenditures and benefits but also a host of non-quantifiable advantages and disadvantages flowing from the research. Engelken identifies a number of factors critical to research success and suggests ways in which these factors can be realized at a regional university. In particular, he notes the importance of multi-disciplinary research, and the role of local and regional funding for the work undertaken. He expresses frustration with the university time scale (which can best be described as "glacial") and industrial perceptions of university resources (which may be viewed by industry as available in the same manner as from a public library).

Strickland, Kannankutty and Morgan discuss industry-academic links as being driven by a number of factors including decreases in industrial R&D funding [Strickland, 6]. They cite a 1995 National Academy of Engineering report that recommends a coupling of academic research and industrial technology, and they note that strong industrial research support is most likely to be associated with collaborating groups of researchers. In addition, Strickland, Kannankutty, and Morgan describe industrially funded research as

> more experimental than theoretical, more synthesis than analysis, more directed to product and process outputs than to publications, less long term focused, and more pulled by the market than pushed by technology.

The same authors see a number of impacts on the academic community engaged in industrial research. The most important of these, perhaps, is the difficulty of maintaining institutional stability and a cadre of talented researchers in light of the inconsistent, short term funding characteristic of industrial research [Strickland, 6].

Cox, Mohr, and Grieve describe efforts of the Center for Industrial Research and Service at Iowa State University and its mission of providing technical assistance to Iowa manufacturers [Cox, 1]. They characterize the assistance provided as including "product design and testing, ISO and QS 9000, constraint management, plant layout, simulation, MRP systems, e-commerce, and productivity improvement". The Iowa State program is distinctive in assigning students to the research involved. Interestingly, initial student training for assignment includes the use of solid modeling software. Student assignment typically is in areas of process improvement, product development, or plant layout, with typical project duration of 1-3 months.

Frey et al discuss the development of academic-industrial partnerships for rapid prototyping and design at a regional university [Frey, 4]. The program involved is described as largely low cost or *pro bono* but has as its goal the objective of providing students the opportunity to apply rapid prototyping and solid modeling to industrial projects. As described by Frey et al, the program has resulted in substantial increases in enrollment. The principal negative aspect of the program is the substantial time commitment involved.

A recent paper by Hidalgo et al discusses the subject of economic specialization [Hidalgo, 5]. Although the authors are concerned with international economic development, they note that productive capacity is limited in its transfer by the infrastructure that is associated with a particular product set. The authors describe the differences in expertise between different products as "connectedness" in an attempt to explain the pace and success of economic development.

Case Studies

The research just discussed provides a basis for the description below of opportunities and problems involved in integrating a program of research and consulting work into an engineering technology program at a typical regional university. Murray State University (MSU) is located in the far western corner of the Commonwealth of Kentucky. Engineering technology programs include civil, environmental, and electromechanical technologies; programs in the industrial technologies are located within the same department. Major industries in the service region include small engine and auto parts manufacturing, industrial chemicals, and food processing. The U.S. Department of Energy operates a uranium enrichment plant in the region, and there are numerous coal mining, oil and gas drilling, and mine service companies in the adjacent western Kentucky coal field. With the exception of the plants in the Calvert City chemical complex, the industries described are geographically dispersed and operate as branches of companies with home offices and technical staffing located elsewhere.

The university poses just the challenges to the development of a research program as described by Engelken, and MSU faculty use almost identical coping mechanisms [Engelken, 3]. While MSU faculty regularly engage in *pro bono* consulting in support of the university commitment to public interest in regional industrial economic development, faculty teaching assignments and expectations for funded research have precluded development of the type of program described by Frey et al. at Southeast Missouri State [Frey, 4] or by Cox et al at Iowa State [Cox, 1]. During the past decade, the research effort of MSU engineering technology faculty has increased significantly. We feel that the experience gained in this area would be of interest to other regional universities, and consequently, we discuss below a series of case studies in an attempt to address the questions posed at the beginning of this paper.

Paducah Gaseous Diffusion Plant (PGDP) Project. This project has been by far the largest effort undertaken to date by department faculty. The project is on-going and has included both part and full time faculty assignments over a period of five years. Project scope involves the computation of a water budget for the plant and development of total maximum daily loads (TMDLs) for heavy metals on the two watersheds that drain the plant. The work consists of significant computer modeling and data synthesis. During the first two years of the project, two faculty, a university technician, and two student workers were assigned full time during the summer session. Quarter time faculty assignments to the project were involved during the academic year. Based on faculty and student involvement in a major research project, and the acquisition of university overhead funding, the PGDP project is consider a very successful project.

MSU involvement in this project was as part of the Kentucky Research Consortium for Energy and the Environment (KRCEE). Contact with other Kentucky faculty had been developed previous to the PGDP project through the annual conferences of the Kentucky Water Resources Research Institute (KWRRI). Contacts made at KWRRI meetings led to a series of joint water quality projects of limited scope. These projects extended over a period of five years and involved MSU faculty and students in field measurement of pH and conductivity on watersheds in the western Kentucky coal field. Funding was provided for travel, student wages, field equipment, and laboratory supplies. Faculty served in a supervisory capacity for both the field work and compilation of field data. These early projects gave KWRRI researchers and MSU faculty a chance to develop working relationships central to the PGDP effort. Without this initial involvement, it is uncertain to what extent MSU would have participated in the PGDP project.

When departmental effort in this project is reviewed, a number of factors are seen as central to its success. First, a dedicated office provided by the department and funding provided by the research sponsor enabled the purchase of computer hardware and software essential to the work. Hence, the research staff had both dedicated space and dedicated equipment. Second, project funding provided some faculty release time. Without this, the workload required by both the project and a typical teaching load could not have been handled. Third, KRCEE administrative personnel were willing to travel to the project site to resolve on-site problems and to support MSU faculty. At the same time, KRCEE technical members consistently shared expertise on technical problems. This was done both formally through quarterly project meetings, and by informal collaboration. Contact and teamwork made a major contribution to the success of the project. Finally, the MSU faculty assigned to the project included an environmental engineer, a hydrologist, and a geographic information systems analyst. The team approach enabled the project staff to take advantage of particular expertise in the conduct of the work.

Western Kentucky Coalbed Methane Project. This project was intended to explore the consequences of coal seam dewatering in association with coalbed methane extraction. Current mining practice in the western Kentucky coal field is to vent or burn coalbed methane. In other parts of the United States, coalbed methane is extracted and marketed in much the same manner as natural gas. However, extraction of the methane is associated with large scale dewatering of the coal seams involved. This project was designed to investigate the characteristics of coal seam water quality and potential environmental impacts.

Department participation in this project was part of a research consortium that included a major industrial partner. Murray State participation in this project was facilitated by faculty consulting (extending over a five year period) with mining companies in the coal field. Faculty assigned to the project included an environmental engineer, a hydrologist, and a chemist. Consortium staff coordinated fieldwork and arranged a site visit to an active drilling operation during the project. Project duration was one year and involved a quarter-time faculty assignment.

The coalbed methane project was considered successful in that project objectives were met and a research report was delivered. Unfortunately, project delays and scheduling conflicts resulted from administrative inertia and communications problems. Routine project meetings incorporating all participants might have avoided or mitigated these problems. In addition, availability of consortium members—or in their absence, a deputy—would have made it possible to resolve issues before issues became problems.

Quality Control and Materials Testing Project. This project followed a request from an area industry to perform materials testing in support of the company's quality control program. The request was made at the time that the company was moving to the region, and consequently, there was a good deal of pressure on the university to respond positively to the proposal. The university response to the inquiry required several weeks of effort by university administrators and faculty before it was concluded that university participation wasn't feasible. The reasons why this effort was finally abandoned merit discussion.

Although the department maintains a testing laboratory in support of academic courses, the lab is not equipped to handle industrial level testing. In the years prior to request, departmental funding had been inadequate to maintain and calibrate an industrial grade laboratory. At the same time, faculty changes and budgetary constraints resulted in courses assigned to the lab being taught by adjunct faculty.

The situation described is familiar to many administrators of technical programs. The decisions made concerning staffing and laboratory expenditures were quite realistic from an instructional standpoint at the time at which the decisions were made. However, lack of both personnel and industrial-grade facilities made it impossible for the department to respond positively at a time of very high project visibility.

While the project proposal did not develop into a funded research program, it is discussed here for several reasons. First, daily departmental operating decisions significantly impact research capabilities. Obviously, not all areas that merit development are going to be funded, but funding and staffing decisions determine not only program direction, but the direction of research as well. In light of ISO 9000 and other quality initiatives, was it realistic to downgrade the lab and turn teaching assignments over to adjuncts? Conversely, in light of a lack of industrial interest, was it realistic to provide additional funding? Second, any research activity needs to be a good fit for both partners. The proposal above consumed a great deal of administrative time and effort before it was decided that what was proposed just wouldn't work. Unfortunately, the decisions that determined university ability to respond positively to the proposal had been made years earlier; regardless of project profile, they were not susceptible to review at that time. Third, university participation in industrial research ultimately depends on faculty expertise. In the project just cited, adjunct personnel having other full-time employment simply could not be assigned to research in the same manner as could tenure track faculty.

Conclusions

The case studies discussed above are considered representative of the changing nature of current industrial research, at least from viewpoint of faculty at a regional university in the southeastern United States. There are a number of common elements in all three case studies above that merit attention, and which provide us with answers to the questions posed at the beginning of this paper.

Build the network. The first question posed was: How does a regional university develop an industrial research/consulting relationship? In all of the case studies presented, an industrial partner was actively involved in the work. While the work provided the department the opportunity to develop industrial contacts, personnel and priority changes make it absolutely necessary to cultivate and develop university-industrial networks to facilitate future research efforts. This can be done through professional organizations, or through meetings of the local chamber of commerce or the manufacturer's association. Further, contacts should not solely involve faculty, but must involve administrators as well.

Infrastructure—physical and intellectual. The second question presented in this paper was: What infrastructure must be in place to facilitate industrial research and consulting? Obviously, the physical infrastructure needed depends on the market in which the university wishes to compete for research dollars. For example, without industrial-grade laboratory facilities, research requiring the lab equipment won't materialize. It is a common misperception that if an industrial partner wants specific services, it will build the laboratory and fund the equipment necessary. The misperception involved is not that this won't happen, but rather that it is likely to happen at the university.

All research does not require laboratory facilities; however, our experience is that even when the research is computational in nature, dedicated space and equipment are essential for successful industrial collaboration. When facilities must be shared, or when dedicated resources are unavailable to other project partners, performance is effected. Likewise, faculty workload cannot be indefinitely expanded. If a faculty member is to be assigned significant research, teaching loads must be adjusted accordingly.

While physical infrastructure is important, intellectual infrastructure is more so. The successful projects described above all involved university research teams. Team development was facilitated by informal contacts within the university community; unfortunately, university structure is such that few professors know the specific expertise of their colleagues in other areas. If such team building is to be facilitated in the future, the university needs to do a better job of internal communication.

University-Industrial Relationships. The final question posed in this work was: How can a long-term relationship between industry and the university be maintained? While the university commitment to research is to some extent within university control, it has been our experience that industrial research schedules, needs, and expectations are highly unpredictable. Our department has learned to cope constructively with short-time-frame industrial projects, lab resource conflicts, and administrative inertia. However, faculty expertise and laboratory development involve years, rather than months, to develop and it is difficult to plan this development without some indication of industrial interest and support. This interest must have upper administration support, and communication with the university must involve both administrative and operational levels.

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References Cited

1. Cox, Ronald, Jeffrey Mohr and Richard Grieve, "Employing students in industrial outreach," *Proceedings ASEE Annual Meeting*, American Society for Engineering Education, Washington, D.C., 2000, Session 1566.

2. De Vries, Marc, "Industrial research and development labs: How they inform science and technology curricula," *Journal of Technology Studies*, Epsilon Pi Tau, Bowling Green, OH, 2000, 26(1), 64-70.

3.Engelken, Robert, "Engineering research at predominantly undergraduate institutions: Strategies and pitfalls for the new engineering educator," *Proceedings ASEE Annual Meeting*, American Society for Engineering Education, Washington, D.C., 1999, Session 0575.

4. Frey, Gary, David Baird, Ted Loso, Raj Desai, and Craig Downing, "Rapid prototyping and design: Partnerships between business and education," *Proceedings, ASEE Annual Meeting*, American Society for Engineering Education, Washington, D.C., 2002, Session 3238.

5. Hidalgo, C.A, Klinger, B., Barabasi, A.-L., & Hausmann, R. (2007). "The product space conditions the development of nations." *Science*, American Association for the Advancement of Science, Washington, D.C., 2007, 317, 482-487.

6. Strickland, Donald, Nirmala Kannankutty, and Robert Morgan, "Forging links between engineering education and industry: the research connection," *Proceedings, ASEE Annual Meeting,* American Society for Engineering Education, Washington, D.C., 1996, Session 2242.

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