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Fostering Strong Interactions Between Industry and Academia

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ABSTRACT

This paper highlights a number of key issues in the development and execution of joint university-industry engineering projects. Government funding reductions have lead to decreased support of university research and economic forces have driven corporations to reduce or eliminate internal R&D centers. These are two driving factors behind the renewed ties between universities and industries. In developing a plan for a joint research project and when working together towards its solution, both sides need to be cognizant of their respective roles to ensure a successful partnership.

INTRODUCTION

Interactions between industry and academia continue to increase in frequency. This growth is a result of the requirements and abilities of both parties involved. Many universities currently suffer from cutbacks in government funding and are looking elsewhere for research support. Simultaneously, corporations have reduced their R&D staff in an epidemic of "downsizing" due to (generally, short-sighted) economic reasons. Many of these corporations still have significant demands in research and development services that cannot be met by their reduced number of staff. This demand can be met by faculty members (and full-time researchers) at universities seeking to develop active research programs. However, researchers (and administrators) at universities must recognize that there are differences when working with industry, as agreements, expectations and time frames for corporations are substantially different than those for the government. Also, engineers (and managers) in industry must understand that universities are not corporate business units nor consulting firms. At a university, the primary objectives are creation and dissemination of knowledge.

This paper discusses some issues in developing a strong cooperative research effort between industry and academia. The paper is divided into two major areas, preparation and implementation, each of which must be addressed if a joint venture is to succeed.

PREPARATION

Before an agreement can be reached and a project initiated, some background work must be accomplished. Preparation is critical in developing a successful working relationship with any individual or group. In this section three critical tasks are presented that foster the development of a strong foundation from which interactive research may be conducted. It is important to note the symbiotic nature of the relationship, i.e., both sides (academia and industry) are necessary for success and both should have significant input in all phases of the project. One commonly accepted view is to assume that industry will provide the funds and a technical problem, and that the university will generate the solution (e.g., in terms of a report). Such a philosophy is not optimal, since there is much to be learned from both sides during the problem formulation as well as problem solution stages. As with any relationship, the success of a joint research effort between industry and academia is built upon trust. Both sides must believe that their partner is willing to work with them and can be trusted.

Identify Needs

The most obvious part of developing a successful project is to identify the needs of the industrial sponsor. Typically, sponsors have a problem (or a "family" of problems) that they desire to have solved. (The problems may range from exploratory research ideas to applied implementation.) Under certain conditions (identified later in this section) the research problems can be conducted by researchers at a university. However, it should be noted that a solution should not be the only objective of a joint project. Another important objective is education of both university and industry personnel. Furthermore, if a university research team solves a problem for industry, the university's role should not be to completely implement and support the solution. That job should principally fall to the industrial sponsors. This must be clear at the start of the project.

To achieve results useful for industry, the university must be actively engaged in educating the sponsors as to the nature and capabilities of the solution (including state-of-the-art techniques, relevant literature such as patents, necessary computer and hardware resources, future potential ideas culled from the research literature, etc.). Quite often the term "technology transfer" is used to describe this objective. To assure success in a project, the company must be able to understand, implement, and support the solution. Technology transfer can take place in several different fashions, including on-site and off-site training. Researchers from the university can play an active teaching role acquainting the corporate personnel about the research results. This approach can be effective, although it warrants a significant time investment from both sides. When possible, the most successful technology transfer comes when the corporate sponsor employs the graduate student who conducted the work (obviously, after the student has graduated). This is, by far and away, the best means of technology transfer. Therefore, it is important that students participating in this work are closely connected to the sponsors. Such connections are also beneficial to the students as it provides them with an excellent head start in the job market.

While the needs of the corporation are (hopefully) satisfied by a solution to a problem and via technology transfer, it must be made clear to the sponsors that the needs of the academic partner are somewhat different. For the university partner it is key that the research conducted is publishable. The publication of a thesis is essential for a graduate student to complete a degree (at most schools), while archival journal publication is important for the faculty advisor's career. It must be made clear to the industrial partner that the research content of the work must be worthy of a thesis and that it will (upon completion) be published in the public domain. Therefore, the supervising faculty member must ensure that the work performed simultaneously aids the industrial partner and supports his/her academic career as well as that of the student.

Scheduling

One of the most common mismatches between industry and academia is the duration of a project. For industry, typical projects are on the order of 6 months to one year. Many managers need to demonstrate results in such a short time frame to secure the funding necessary to support a project and to be successful in their careers. However, most academic projects are on the order of 18–24 months for a master's degree and three or more years for a Ph.D. project. It is critical that the scheduling of a project be clarified at its inception and that both sides clearly define their requirements.

In our view, it is ill-advised to pursue a project involving a graduate student when the project has a duration of less than 9 months. Such a project is better tackled as an undergraduate project since it probably would not have enough research content to warrant a thesis. If a short project does have enough depth to warrant a thesis, then more than likely, it should be treated as a consulting project pursued by the faculty member. (For a short-term project, this is an excellent means to build trust, and test whether a larger partnership would be worthwhile.) Asking a student to conduct a high quality thesis in less than 9 months is an injustice to both the student and the project.

The best solution to the timing issue is to identify projects that match the academic time frame. However, this may not always be the case. In such an instance, shorter master's level projects on the order of one year are acceptable provided that the student working on the project has completed one to two terms of graduate studies. For example, the student may have taken a number of courses while supported as a teaching assistant (TA) in the first two semesters. During that time, the student should complete the set of courses that enable him/her to concentrate on research during the span of the project. Furthermore, the advisor should work with the student to build the necessary basic skills required to conduct the research. A number of courses that we have found to be useful for students working on industry projects include statistics, probability, manufacturing, signal processing and controls. It is also desirable to have the student serve as a TA in courses that will enhance research skills even further. For example, when preparing a student to work on a machine tool analysis project, we have strongly encouraged the student to serve as a TA for undergraduate courses in the areas of manufacturing, signal processing and control. By teaching recitations and grading homework problems, the student truly masters the material and attains a high level of competence.

Proprietary Information

Companies often request that universities engage in research of a proprietary nature. Although agreements can be worked out between the legal departments of a university and an industry, we would discourage university researchers from pursuing fully proprietary work as it violates the academic spirit of publication. As previously noted, the most tangible results of research conducted at a university are publications. To complete an advanced degree where a thesis is required, the thesis must be made public. However, in many instances, information provided to university researchers is proprietary and must be treated as such.

The key to resolving this issue is an early understanding of what is publishable and what is not. Well before any agreement is reached, the scope of the publishable research content (e.g., the material that can be reported in a thesis) should be discussed in detail and understood by both parties. This eliminates a number of potential future problems. It helps to clarify the goals of the project to ensure that both the academic and industrial needs are met. Furthermore, it identifies what types of results will be put in the public domain (assuming a research contribution is attained). An early understanding provides the sponsor with an avenue to control the flow of sensitive information. It also informs the researchers of the information considered proprietary and sensitive. Without such an agreement at the outset of the research, significant difficulties can arise such as the sponsor requesting significant changes in a nearly completed thesis.

A number of other approaches can be used to allay corporate resistance to publication of sensitive information. Agreements can be crafted in which thesis publication is delayed after completion of the work. Typically, the language of such agreements states that the thesis will be published no more than one year from its completion date. Another approach is to publish results related to more generic products and/or materials to avoid providing specific information such as actual materials used or tolerances or production rates.

IMPLEMENTATION

Once the research plans have been identified, the project can be conducted as most other research projects. However, there are two critical tasks that should be considered when working with industry.

Working Together

In order to ensure that the project is meeting the needs of industry, it is important that the academic supervisor maintains close contact with the industrial sponsor. Clearly, research is an "open-ended" process (it has to be or else it is not research). As such, it does not have a fixed path nor a fully known set of results *a priori*. Therefore, the advisor and student need to make decisions as to the direction of the work. This is best accomplished with input from the corporate sponsor. All too often, academic curiosity leads to interesting results; however, these results may not be the ones desired by the company. To this end, communication is critical and should happen frequently, ensuring that that project is addressing the questions posed by the sponsor as well as meeting the requirements for the academic institution.

Supervision of Students

If at all possible, students (and their advisors) should spend some time at the corporate sponsor's facility. It is most convenient if this facility (e.g., manufacturing plant, corporate headquarters, etc.) is local. In this case, the student should spend a day or two per week at the sponsoring facility. This will provide the student with a thorough understanding of the objectives and direction of the research as well as excellent resources (including access to key individuals).

Furthermore, as schedules for industry sponsored projects are usually fixed, it will be important to closely supervise the student to keep the project on schedule. If a project is to be completed in one year, then it may not be acceptable to the sponsor to have it extended by a month or two. Often the project is only a small part of a larger set of goals and it must be completed on time in order to be coordinated with other goals. In academia, a student may take an extra term to finish his thesis and may be funded as a TA or may even take a job and complete writing the thesis while working. This may be acceptable from an academic perspective, but such flexibility is often not a possibility for industry.

PLANNING FOR THE FUTURE

In closing, it seems appropriate to mention a few issues to be considered in developing a long-term relationship between academia and industry. First, as projects are being completed, both sides should be in close communication, exchanging information and being assured that the project goals are being met. As a project is nearing completion, the two partners should be laying out the next phase of the project. If the sponsor is pleased with the work, he should seriously consider the possibility of hiring the student. (It is not often that an employer and employee have the opportunity to evaluate each other for one year before making hiring and career decisions, respectively.) In communication with the sponsor, it is critical that the faculty member does not solely represent his individual research capabilities, but those of the entire university (and even experts elsewhere). No individual can be an expert in all areas of interest to industry; however, a single contact at a university can be a conduit to a number of experts.

Universities are capable of conducting high quality research for industry. They can provide powerful and cost effective research facilities if utilized properly. Engineering academic institutions continue to state that they are interested in real world problems; therefore, they must meet the needs of industry. However, industry and academia are two significantly different environments and must be integrated in a careful manner with sensitivities to the realities of both sides. If such a “marriage” between the two is achieved, the results can be mutually beneficial for both the parties. The outcome of collaborations include cost effective research for the industrial sponsor, real-world research projects for the faculty member and students, and a well grounded thesis as well as excellent experience for students. All in all, joint university-industry collaborative research projects can be viewed as “win-win” situations when initiated and executed in the appropriate fashion.

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BIOGRAPHICAL INFORMATION

Professor Thomas Kurfess received his S.B., S.M. and Ph.D. degrees in mechanical engineering from M.I.T. in 1986, 1987 and 1989, respectively. He also received an S.M. degree from M.I.T. in electrical engineering and computer science in 1988. Following graduation, he joined Carnegie Mellon University where he rose to the rank of Associate Professor. In 1994 he moved to the Georgia Institute of Technology where he became an Associate Professor in the George W. Woodruff School of Mechanical Engineering. His research work focuses on the design and development of high precision manufacturing and metrology systems. In 1992 he was awarded a National Science Foundation Young Investigator Award, and in 1993 he received the National Science Foundation Presidential Faculty Fellowship Award. He is a registered Professional Engineer, and is active in several engineering societies, including ASEE, ASME, ASPE, IEEE, NSPE and SME. He is currently serving as a Technical Associate Editor of the SME Journal of Manufacturing Systems, and Associate Editor of the ASME Journal of Dynamic Systems, Measurement and Control.

Professor Mark Nagurka received his B.S. and M.S. degrees in Mechanical Engineering and Applied Mechanics from the University of Pennsylvania in 1978 and 1979, respectively, and his Ph.D. degree in Mechanical Engineering from M.I.T. in 1983. Following graduation, he was an Assistant and then Associate Professor of Mechanical Engineering at Carnegie Mellon, where he taught courses in the area of system dynamics and control. In June 1994 Dr. Nagurka became a Senior Research Engineer at Carnegie Mellon Research Institute (CMRI), where he was actively engaged in R&D projects in the area of transportation. In August 1996, Dr. Nagurka joined Marquette University, where he teaches courses in system dynamics and mechanical measurements & instrumentation. His research work focuses on the development and integration of control methods into practical mechanical systems. Professor Nagurka is a registered Professional Engineer, and is active in several engineering societies, including ASME and IEEE. He is a Technical Editor of the Applied Mechanics Reviews, and served as Technical Associate Editor of the IEEE Control Systems Magazine.