AC 2007-1154: REWARDS AND CHALLENGES OF UTILIZING UNIVERSITY RESEARCH/ECONOMIC DEVELOPMENT CENTERS FOR ENHANCING ENGINEERING EDUCATION

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Abstract

Most professional disciplines have an integrated residency period for their students before they graduate. This is certainly true for medical and law schools. In engineering, however, this practice has not been formalized. Some schools accomplish this task by their co-operative engineering education programs. In some other schools, students gain experience in summer internships. However, in most universities these programs are optional and, where conducted, take place with minimum contribution from the university professors and professionals.

At the same time, due to expectations from universities to play a more direct role in the regional economic development many universities have established research, technology transfer and technology commercialization centers to serve this purpose. These centers partner with the federal government and local private industries to assist the regional industries to develop new products and processes for the partner industries to implement. The ultimate hope is to bring along the technological innovation to the region and create additional jobs and economic development for the region.

Having these centers owned and controlled by the university, like teaching hospitals that are operated by medical schools, provides a great opportunity for advancing engineering education. Consequently, it is no surprise that some (though not as many as there should be) colleges of engineering have taken advantage of this opportunity. These colleges have established an internal internship program through which engineering students are hired as part-time interns and work as a full fledged engineers on projects contracted with the industry. Although the advantages of operating these centers in terms of the quality of graduates have been positively proven by several centers, the challenges in establishing, maintaining, successfully financing, and efficiently operating them have been great obstacles for other universities to follow.

This paper is a compilation of observations from the authors regarding the challenges and rewards to set-up and operate a research/economic development center in a manner that enhances the education of engineering students. The authors have been actively involved in developing and operating the two centers that are operating successfully in two different universities, Kansas State University and University of Massachusetts Dartmouth.

Introduction

Due to changing expectations many universities have moved toward establishing research and technology transfer centers that directly work with regional industry to help them to adopt advanced and innovative technologies. These centers that are owned and operated by the university, like teaching hospitals that are operated by medical schools, provide great opportunities for advancing engineering education as teaching hospitals help in educating of medical students. Consequently, it is no surprise that some colleges of engineering have taken advantage of these centers in a variety of ways. Several colleges have established internal internship programs through which engineering students are hired as part-time interns and work as engineers on projects contracted with the industry.

In these centers which are equipped with research, design, and manufacturing facilities for innovative product and process development, teams consisting of usually two to five undergraduate student interns from variety of disciplines are formed and assigned to each project. Each team is supported by a professional staff member with extensive engineering experience. The industry provides funding and real engineering projects for the center. Centers, in return, utilize student interns and the professional staff to provide technical assistance and technology transfer to the industry. In addition to an excellent hands-on engineering experience for students, the major contribution of such an environment to enhancement of engineering education is to advance students' abilities to learn non-engineering skills so crucial to becoming a skilled engineer. As students get involved in becoming the primary engineering resource behind these projects, they learn how to address the business, economic, social and communication aspects of a complete engineering project.

In 1995 the Advanced Manufacturing Institute of Kansas State University started operating its Engineering Learning Center. The Advanced Manufacturing Institute (AMI) is a research and technology transfer center created to utilize university resources to assist in enhancing the economic development of the state. Engineering Learning Center is an integral part of AMI's operation. The objective of creation of the Engineering Learning Center (ELC) was to use the business-like environment created by AMI to enhance the education of engineering students. It was believed that by actively contributing to AMI undergraduate students will gain those aspects of engineering experience that are perhaps impossible to teach in classrooms. This center was funded by grants from National Science Foundation, Department of Commerce, Society of Manufacturing Engineers, state of Kansas and many small to medium size manufacturing companies. In 2001, after moving to the University of Massachusetts Dartmouth, the initial director of AMI established the same student internship concept at the Advanced Technology and Manufacturing Center (ATMC) which had just been started with the same mission as Kansas State's AMI. Both centers operate in a similar fashion by contracting with the industry and utilizing student interns under the supervision of experienced engineering staff to serve the industry.

This paper briefly describes the mode of operation of both centers and advantages to both students and the client industry. The paper then focuses on the challenges that need to be overcome in establishment and operation of these centers. Finally, recommendations are made for successfully responding to those challenges and strategies for maintaining the operation of

such centers. The authors would like to state that what is presented here is based on their personal experiences in operating these centers for close to fifteen years. They hope that additional discussions on these issues by other directors and operators of centers with similar missions will contribute significantly to the adoption and success of more such centers.

Mode of Operation

The Advanced Manufacturing Institute operates a full service engineering and manufacturing facility located at an industrial park. The full-time staff consists of many experienced engineers, technicians and support personnel. On average, 35 student interns are employed who work an average of 15 hours a week during the school year and longer hours during the summer and midterm breaks. The involvement of students at the center serves two objectives. First, they provide an invaluable service in designing and developing new solutions for industrial clients. Second, they complement their academic education with the hands on real engineering practice by working on projects for paying customers. Their technical education in the center is coordinated by a faculty advisory committee consisting of one faculty from each department. Their professional training is supervised by experienced engineers who are project managers for the projects students develop.

New student interns are hired every semester from among juniors through a nomination/application and interview process. Nominations are made by departmental representatives on the faculty advisory committee of the center who provide the list of eligible students to the ELC director. Students may also submit applications directly to center personnel. Students are interviewed by the ELC professional staff and those who are selected are notified to join the internship group at a designated time. Continuing interns are evaluated by their engineering supervisors and are either approved to continue their internship or are discharged if their performances are judged to be unsatisfactory. Interns are paid an hourly rate that rises moderately as they continue as successful interns. At any given time the center has a group of interns who are either assigned to a project or are available to be assigned to new projects. The mode of operation at the Advanced Technology and Manufacturing Center of University of Massachusetts Dartmouth is similar. However, as this center is younger the volume of activities have not yet picked up to the level of operations at Kansas State University's AMI.

Industry projects are identified and defined by the experienced staff engineers of the center. These engineers also develop the contracts along with the deliverables and associated budgets and get them signed by the university and the client company. After the project is approved, it is assigned to a team of students for implementation. The membership and the size of the intern teams vary depending on the nature of the work. The team is usually interdisciplinary and includes students from several engineering disciplines such as mechanical, electrical, industrial, chemical, etc. It also may include students from some non-engineering disciplines such as chemistry, physics, or business.

The main responsibility for successfully conducting projects lies on student interns. They are responsible for drafting the time table for project activities, designing products, prototyping, and in some cases coming up with the required manufacturing processes. An important aspect of most of the projects is the communication component. Students are in charge of all the internal

and external communications. They prepare progress reports, discuss the bottlenecks with client companies, and communicate with all suppliers and vendors of materials and services necessary for completion of the project. In some projects they are also in charge of implementation of the solution in the client companies' facilities and providing a portion of the after delivery services.

On the average, students spend two years as interns after which they graduate both from the center and from the university. The demand for graduates has been extremely high and very hard to keep up. Several graduates have been hired by the client companies for whom they have completed projects. At the University of Massachusetts Dartmouth, where the center is integrated with an incubator, many graduates have been hired by the startup companies at the incubation phase in the center.

Rewards

Rewards from operating these research/technology transfer centers have been remarkable. These rewards could be categorized in three groups: economic development, social impact, and the effect on enhancing engineering education.

In economic development terms, these centers have helped clients to improve their firm's competitiveness, helped to incubate new ideas and businesses, and developed new products. These projects have resulted in the creation of new products, increased sales, reduced costs, creation of new jobs, and retention of existing jobs.

The social impact of engineering students working on real problems that concern local industry has significantly been felt by both the industry and the communities around the centers. When the centers started, we expected that the technical assistance provided by the center would be the only motivation needed for the industry to collaborate with these centers. We soon found, though, that just getting our phone calls returned by the people in the industry was a challenge. However, as the center staff persisted with delivering the right solution on time and under budget, more and more companies were attracted. After a few years, to our great surprise, many of the industrial collaborators of the centers assumed a stronger role than just being the providers of projects for the center. They started claiming ownership in the education mission of the center and acting as goodwill ambassadors for the center and the university with the state officials and legislators.

The impact on student education, however, was the biggest reason for our center's to be built. It is clear from many studies that the major contributor to the technology transfer is the education of people who carry the technology with themselves from the university to companies. This contribution, however, was not readily realized by the industry until they got their hands on it and felt it closely as they saw the work done on their project was easily transformed to their companies. Time and time again the college and the center were praised by employers for the quality of the graduates with this internship experience. Many smaller companies are often reluctant to hire engineers because they cannot afford to pay and wait for the year that it usually takes for a new graduate to become productive. Graduates of these centers, however, soon became recognized as engineers who are ready to hit the ground running. This occurs because

these students have had significant mentored engineering experience. Furthermore, many times this experience is directly related to projects that they did for their future employers.

The details of operations, examples of projects, and facilities and capabilities of AMI and ATMC have been explained in several publications referred to at the end of this paper. As mentioned above, this paper is meant mostly to elaborate the challenges for getting such centers established and maintaining their engineering education mission.

Challenges

Funding and operating centers like AMI and ATMC are amongst the greatest challenges to face a center director. To start-up an operation like these, one must first identify potential investors/stakeholders who are willing to invest in this operation to gain the expected rewards discussed above. Unfortunately, different stakeholders have different expectations that are not necessarily complementary.

For example, stakeholders interested in the economic development potential of this activity are primarily concerned with economic results. These results can be obtained by executing each and every project in a professional manner; in effect, doing the same thing over and over again. On the other hand, stakeholders interested in enhancing engineering education are primarily concerned with determining ways in which universities might develop better engineers. For example, NSF has provided major grants that helped to build AMI and ATMC. In each of these grants, new activities were proposed, developed, analyzed, and reported. NSF does not have sufficient resources to implement successful operations across the country and is not typically interested in funding day to day operation of centers like AMI and ATMC. Instead, they fund new experiments and the exploration of ways to enhance the education of engineering students. These activities are taken on by center personnel in addition to their current duties. With each new grant come new responsibilities. To continue to take on new responsibilities begins to cut into the ability of the staff to manage projects and interns. This funding model cannot sustain the operation of ongoing activities and so the center director must find alternate means of supporting the center.

To sustain centers like AMI and ATMC, government agencies provide funding to leverage university resources for technology-based regional economic development. Even so, there are many challenges one faces in trying to build and operate these centers in a way that not only serves the economic development mission, but also contributes to the education mission of the university. In this paper we will explain these challenges in terms of a series of *"myths"* that are very common among university administrators, faculty, and the general public.

Myth #1: **If you build it, they will come**

Many leaders of the university and the community believe that if the university starts a center that has access to the faculty expertise and laboratory and other facilities that the industry could utilize, the private sector will break the doors to get in and use the services. This, unfortunately, is not true. There are two classes of gaps between the industry and the university environments: *Cultural Gaps* and *Motivational Gaps*.

Cultural Gaps

The list and comparison of some of the cultural differences are given in Table 1.

| Table 1: Cultural Differences Between University and Industry Personnel ||
University	*Industry*
Time available for a perfect solution is unlimited	*A limited time is available to find a good solution*
Once the highly intellectual part of the problem is solved interest diminishes	*Only 5% of the problem is intellectual, the rest is leg work*
Faculty are used to customers who prefer getting less for their money	*Industry is used to customers who insist on getting more for their money*
Attention on resources: money is a resource to continue explorations	*Attention on results: money is the metric by which each project is measured*

The effort to find a perfect solution to a problem is often a never ending endeavor at the university and this is quite reasonable in an academic environment. If a project is not done by the project deadline, simply request a no-cost extension and keep working until the project is done. Industry, on the other hand, is interested in solving a particular problem, even if the solution is not perfect, in the time that makes the solution commercially viable. This difference, perhaps, is the most contentious when the industry goes to the university for a solution to a technical problem.

The second factor is the intellectual value of providing a technical solution. Most faculty members are interested in the most difficult aspect of the problems they solve. They lose interest when the discovery is made and the proof of concept is accomplished. Industrial clients, though, know that discovery is only a small portion of implementing an advanced technology. Much more time, effort, and energy has to be spent in getting a product to the market faster, cheaper and better than the competition can.

The next factor is faculty's perception of the customers. Most of our customers at the university are students. Students often are not very demanding customers. Very few students will criticize a professor for not covering more material in a course or demand the professor stay in the class after the bell has rung. If a class is ended after thirty minutes instead of fifty minutes, many of our customers will appreciate it. Having gotten used to this customer behavior, sometimes faculty are annoyed that the industry wants them to work more than they think they should. And they are even unhappy if the clients want things to actually work! Industrial clients, of course, do not help much either. In many situations, for very little investments they make on a project given to the faculty, they expect faculty members to provide the required support for the rest of their lives.

The last factor is the view of money. In the university, faculty members acquire grants in order to support graduate students to continue and expand their research. It is, in effect, a necessary evil that is required to accomplish university's real purpose: the advancement of science, knowledge, and education. The goal is to acquire enough money to accomplish sound research projects and develop sustainable research programs. On the other hand, industry views money as

the basic metric of its performance. Knowledge is a source of competitive advantage that can be used to build stockpiles of money to be distributed to employees and stakeholders. The goal is to maximize financial returns on the money that has been invested in the company, both in the short and long term.

Bridging the Cultural Gap

Several steps have been taken at both AMI and ATMC to bridge these cultural gaps. The main action has been to hire experienced engineers to act as project managers for projects contracted with industrial clients. The role of faculty in these centers has changed to consultants who contribute to solving the high level scientific aspects of the requested technology from the industry. The other contribution from faculty members occurs when the technology being transferred to industry has been generated from the research conducted by the faculty and their students. In these situations intern teams work on prototypes and other processes to get the results of the research closer to commercialization.

Full-time engineering staff of the center do not have faculty appointments. Their primary job is to mentor students and to make sure projects are done on time and that the results are satisfactory for the clients. They are also responsible for visiting industrial clients, preparing contracts and initiating projects. In visiting companies the engineers play a dual role: they receive inputs from managers and owners of corporations regarding their immediate and long term problems. At the same time they provide industry clients with information about new areas of research that are going on in the university along with information on faculty and university expertise. This two-way messaging has been shown to be a very effective tool in getting faculty interested in solving some short-term problems and encouraging industry to collaborate with faculty for some long-term research-based technological innovation.

The next strategy employed by AMI and ATMC is to introduce the concept of internal engineering internship into the operation of these centers. This innovative engineering education process has had a major impact on the success of centers' contribution to university's education mission while facilitating its economic development mission. Students provide the leg work necessary for hardening the technologies for the client companies. Student interns conduct all engineering functions necessary for the success of the project. The main responsibility of project managers in charge of these projects is to mentor students to complete projects successfully. The experience with having students take the major responsibilities has been surprisingly rewarding for both the university and the client companies.

Motivation Gaps

Another factor that poses a challenge in making these centers successful is the difference between the motivation of a typical university faculty and that of a given company. Table 2 lists a sample of these differences.

Even though there have been a lot of claims at universities regarding the importance of community service, in the final analysis, what counts for faculty members to advance in their profession and get tenure and promotions are their scholarly activities: publications and

obtaining prestigious federal grants. The same factors influence the faculty member's recognition in their professional discipline. Working on small contracts that may or may not satisfy the client company does not often play a major role in the career of faculty. This is particularly true for new faculty members.

Table 2: A sample of Motivational Gaps between University and Industry Personnel	
University	*Industry*
Advance knowledge/education	*Make money*
Contribute to the world of technology/solving society's problems	*Create and develop wealth – make money from new products*
Find elegant solutions for complex problems	*Find a solution for a specific problem; elegant or not*
Publish papers	*Keep secrets for competitive advantage*
Become a big hit in scientific or professional circles	*Expand or at least stay in business*
Support graduate students to expand the faculty members efforts, contributions, and reputation	*Only support projects that provide the best value for investments while protecting competitive advantage*
Generate summer salary/Make money for the university	*Generate a return for investors/stakeholders*

The key difference between the motivation of university faculty members and industry is found in their basic missions. The university exists to advance knowledge and educate students. Companies exist to make money for investors. All the other differences in motivation are derived from these basic differences in mission.

For a faculty member to be successful in his research, he/she will need to support graduate students. The financial support for graduate students must last at least for two years. Industry contracts are often for a shorter period of time and do not match the time schedule for completion of a thesis. Government grants, on the other hand, are for longer periods and the results do not have to be implemented in a short period of time. Motivation for making money exists among the faculty, but it does not take the highest priority. Besides, many universities do not allow faculty to make more money than their salaries during the academic year. As a result, faculty members have to go through the complicated process of providing the service during the year and getting paid during the summer.

Industry motivations are diametrically opposed to university motivations. Making money and maintaining the business and trust of the customers is clearly the highest priority. Other motivations such as personal pride or being a contributor to the world of technology are certainly not as high a priority as making money now and in the future.

Overcoming Motivational Gaps

Although motivational gaps seem to be too deep, there are ways to get around them. First of all, the centers have hired professional personnel who are charged with achieving the center mission. These industrially experienced professionals carry the bulk of the burden of conducting center activities on a day-to-day basis. Second, the motivational gaps listed above may be true for some faculty but not for all. There are faculty members who have earned all of their promotions and are not very much interested in obtaining fame in their areas of research. Some of these faculty members may personally be interested in working on projects with immediate results. Some might even be able to satisfy the demand for both highly theoretical and applied research at the same time. In fact, some might be able or even eager to channel some of their state-of-the-art research into some practical applications or technologies that could be commercialized. The fact is that a center does not need the collaborations from every faculty in the college or the department in order to be successful. The collaboration of just 5% of the faculty members can be sufficient to achieve the center's objectives.

Another factor to keep in mind is that the center can still help the faculty members to achieve many of their goals. Many federal grants look for evidence of industrial collaborations. Centers can be instrumental in establishing industrial relations for the faculty. Furthermore, contracts with industry can help the faculty to support some graduate students to do preliminary work that could later lead to the development of major research proposals. Of course, some additional support for summer salaries and travel funds do not hurt. In addition, the center may help some faculty members to commercialize the results of some of their research.

Myth #2: **Centers will become self sufficient through industry funding**

In starting all centers such as AMI and ATMC the initial expectation is that the center will become self-sufficient after a few years of state investments. It is unfortunate that this wish is neither possible nor desirable. Self sufficient centers are not good candidates for economic development. The first victim of trying to make a center self-sufficient is the educational mission of the university. Self-sufficient centers do not have inclinations for spending money to enhance education. All efforts of such centers will be focused on earning enough funds to keep the center operational under any circumstance. Furthermore, a self sufficient center will have no obligation to assist the companies that the government most desires to help. In order to make a center self sufficient client companies have to bear the total cost of conducting the project, including the university's overhead (facilities and administrative) costs. Consequently, the cost to the client could end up being even more than if they hired an outside consultant.

Overcoming the Financial Issues

In order for centers to operate with financial health and at the same time serve the education and economic missions of the university some of their funds should be recurring and paid by the university or the government. A 3-way split between the private industry, state government, and federal grants is a good approximation for the budget for the center. The funds beyond and above the direct cost of conducting projects is necessary to pay for the basic research that eventually may or may not turn into a technology for commercialization. It also has to pay for learning

periods for students, faculty and staff for getting involved in new projects on the regular basis. In general, industrial clients are not willing to pay for this learning. Finally, based on the experience we have had in operating these centers it is essential for the center not to go in debt to get it started. They should own their equipment and other research and production facilities. Several centers that started with borrowed money did not last long.

Myth #3: Centers are economic development agencies

It is common among some university administrators and state legislators to refer to university centers as economic development agencies. This term is often misleading. In general, centers are not economic development agencies. They have some common components with economic development agencies as is demonstrated in Figure 1. The intersection between the university and the economic development activities is where the center's operations should be located. In general, one could say that the economic activities of the university that do not contribute to the university's research and education mission do not belong in the university.

EDUCATION AND RESEARCH   **ECONOMIC DEVELOPMENT**

Basic Research   Loan to Business

Technology Development

Serving the Profession

Teaching

Applied Research

CENTER ACTIVITIES

Relocation Allowances

Training Labor

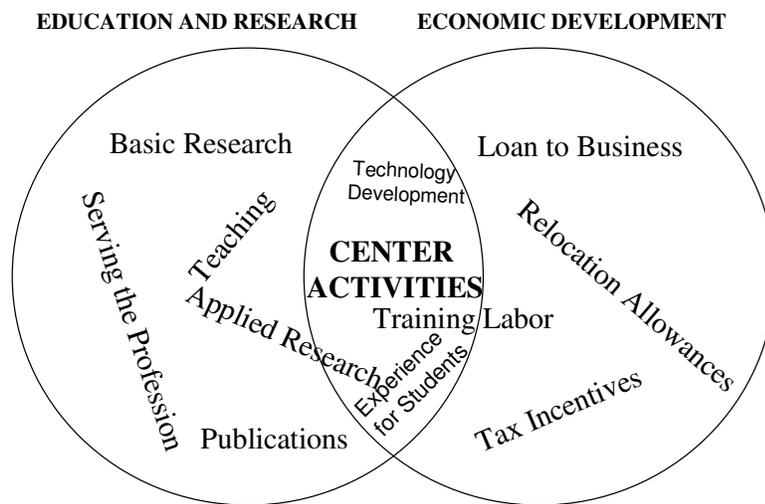Experience for Students

Publications   Tax Incentives

Figure 1. Overlap between university activities and economic development agencies actions

To be sure, the results of center activities can have a significant economic impact. However, each project is intended to directly benefit an individual client in a manner that "scratches their itch." There is no grand plan for developing a local, regional, or state-wide economy. The objective is to help the client and to enhance the education of the engineering student while doing so.

Myth #4: Industry trusts Universities

This statement is not generally true. It is true that the industry trusts universities to educate engineers with adequate knowledge to serve their needs. They also trust university and university

professors as knowledgeable and good people. However, when it comes to giving their hard earned money to universities to do a project for them, the trust is usually not there. The general comments we have heard from leaders of the industry (when they trust us enough to be honest about it) has been in statements like:

- Universities are expensive, tardy and never deliver
- We pay universities once with our taxes, once again with fees for projects, and still they want us to pay royalty for the projects *we* funded
- They look down at us

Earning the trust of industrial clients

Our experience has shown that earning the trust of an industrial client takes a long time and a lot of hard effort, but when you succeed it is well worth the effort. The client is in business to make money. They do not mind paying money when they are reasonably sure that it will make them more money. This has got nothing to do with them being generous. Often our request for receiving a donation of $100,000 from a company has been more successful than getting a contract from them worth $10,000. Donating $100,000 to the university fulfills a different objective of the company than paying $10,000 for a project. For them it is often easier to justify a $100,000 charitable donation than a $10,000 business expense that did not bring them anything. According to our experience, the following steps go a long way in helping to earn the trust of an industrial client.

- Showing personal interest in their business. Visit them. Don't just send them a flyer. Universities are sometimes intimidating places for industrial clients. There typically isn't a receptionist who can show you where to find a particular professor nor is there even a convenient place to park on most campuses. These factors are enough to turn many potential clients away from working with faculty in the university. Industrial clients, particularly from smaller companies, would much rather meet faculty members on their own turf than in the university. Faculty, in turn, can also learn quite a bit by visiting the company.

- Start with a small project that you are sure you can deliver successfully and bring profitable results. These successes will open the door for larger and more complex projects. Many faculty members are used to getting federal grants worth several hundred thousand dollars for which there is a good understanding that if there is not a practical result it is still ok. Publishing a few papers would be just fine. Companies, especially smaller ones, cannot afford such expenditures. At least not in the beginning. Our experience shows that after a few small projects, even small companies may accept the risks of investing in larger projects.

- Dividing projects into phases with gates from one phase to another is a very useful business practice. This allows both sides to back off anytime they feel the project is not going to be successful. This ability to reconsider will save a lot of heartaches, if not lawsuits.

Myth #5: All industry expects from a center is a technology that is cheap and works

The first problem with this statement is that some industrial clients assume that they can get quality work done by the center for much less than they would have to pay for the work to be done by other providers. The fact of the matter is that center projects are rarely much less costly than the same project would be if done by another firm. The center typically must pay the same university overhead rates on these projects as are required for federal grants. Secondly, though students are paid less than full-time staff and provide most of the engineering tasks for projects, they are much less efficient than a full-time, experienced engineer would be in accomplishing a project. Consequently, there will be more mistakes/learning in a project and the client must also pay for the experienced engineer to mentor the students to complete the projects.

Having said so much about how companies do not trust universities, it is interesting to share our experience about their attitudes when they finally trust universities. Companies are interested in building relationships with universities. By going to universities, companies value the relationship more than the technology they might receive. We have many examples of leaders of companies, who after having been involved with a few projects with the center, take the role of crusaders to support the university's missions and fight for more resources for the university. Many of them become supporters of the center and bring more projects to the center, not just for getting a good solution, but for helping to educate engineers they feel would be great additions to their companies.

Myth #6 Universities' Intellectual Property policies are understood and valued by industry

This is perhaps the most underestimated assessment dealing with industrial projects. Large companies are savvy intellectual property owners and licensees and are not afraid to negotiate with the university for terms they find acceptable. Smaller companies, on the other hand, are very concerned about the big university somehow cheating them out of what is rightfully theirs.

Most universities, by law, are the owners of the intellectual properties for everything developed at the university. On the other hand, when a company pays for a project to be done at the university it expects to own the intellectual property that resulted from the work. This often creates a major problem in signing contracts. Even worse, are problems that can result after the project is done if both sides do not negotiate intellectual property issues prior to undertaking the project. Many of the intellectual property issues are the result of limited understanding of what it actually means. For instance, if a company is told that they could have the right to use the result of the research but they have to pay certain percentage of their revenue from the technology to the university, they might easily accept it. However, if they are told they could use the technology but the university will own the intellectual property rights and not their company, they will not even sign the contract to begin with even though these two conditions are very close to each other for most practical purposes.

Getting around Intellectual Property Issues

Having a friendly attorney and a savvy university technology officer with can-do attitudes is extremely useful. As mentioned above, explaining the general difference between owning the patent and having the right to use it will help the contracting issue be solved much more quickly.

A short contracting instrument is essential. Many projects conducted in centers like AMI and ATMC do not end up with results that are patentable. But this is not known in the beginning. A thirty page contracting template given by the university to the company will encourage the company to have it reviewed very carefully by their lawyers. Our experience has shown that this process is very lengthy and in many situations results in the contract not being signed. A short contracting instrument (a two page agreement) with a provision for future negotiations if intellectual property rights become an issue, has worked effectively.

Other factors necessary to build a center

- A Champion is absolutely necessary, because in the beginning there are a lot more discouraging elements than those that encourage.

- A strong institutional support is a must. A lonely champion will have to deal with a lot of resistance from other competitors in the university. There will also be external factors that the university has to fight to get the center going. Without the support from university higher administrators one should not even try to start a center.

- Centers will need an initial start-up funding and a continuing annual budget that covers some of the basic expenditures such as salary for the director and a small office support. It will also be very helpful if the center can afford an ongoing research initiation fund for several faculty members to build the base faculty support.

- Finding the right staff for the center is absolutely critical. The engineers need to have industry experience, be quick learners, excellent communicators, and patient mentors. The center should start with a few experienced engineers to begin with and make sure that they are successful in their first projects. Additional funds for increasing the number of professional staff members should come from the revenues of the center as the number of projects grows.

- A student intern program is necessary, because this program will provide a pool of very intelligent engineering force while fulfilling one of the center's main purposes that is serving university's education mission.

- A ton of patience in the center director.

- A hands-on one-on-one marketing strategy

A Few Helpful Responses

Finally, we would like to end this paper with a few responses we have learned to provide to people who have concerns in working with the center. Following questions have often been asked from us over the past fifteen years. Some of these are not simple to answer. Following are some of the questions and the way we have answered them:

Question: "I pay taxes; you should not charge me for services"

Our Preferred Answer: Only a small fraction (less than perhaps a penny for a $100,000) of the taxes paid by one company goes to the center to pay for a project, the rest is paid by others.

Question: "The center is to create new jobs. By pushing advanced technologies you are eliminating jobs"

Our Preferred Answer: Advanced technologies create new products that can generate sales and increase jobs as well as improve the efficiency of operations that eliminate some jobs. Even when jobs are eliminated, the remaining jobs are typically higher paying jobs. Without this help all existing jobs may be lost.

Question: "When will you be self sufficient?"

Our Preferred Answer: The goal of making these centers self-sufficient may hurt their main purpose which is to assist companies who really need their services. A self sufficient center may concentrate more on making the ends meet than to serve economic development of the region. A partial support from the university, state and federal government will assure more attention to regional economic development and educating students.

Summary

There is no easy, step-by-step procedure for developing and operating centers like AMI and AMTC. Developing and operating centers like these is not for the weak or faint-hearted. There are daily challenges to resolve the clashes between university and industry cultures. Funding and operating the center is a continuous battle that requires both creativity and tenacity.

On the other hand, these center's are truly models of how one might significantly enhance a solid engineering education while simultaneously helping entrepreneurs and clients to solve their engineering problems and develop and bring new products to market.

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