

# An International Engineering Research and Exchange Initiative

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**Abstract - Globalization is producing significant changes in the engineering profession. In response, Marquette University's College of Engineering is examining ways that cooperation with international institutions can improve the effectiveness of teaching, research, and research commercialization. This evaluation has led to the inception of an initiative in entrepreneurial engineering, defined as the development and transfer of technology into commercially viable products and services with sustainable competitive advantage in the global marketplace. A key element of this effort is the development of an International Engineering Research and Exchange (IERE) initiative to: 1) create an international learning and research environment that prepares students to effectively function on global entrepreneurial teams; 2) generate global technology-oriented business opportunities through international student and faculty entrepreneurial project teams; 3) establish long-term partnerships with international educational institutions to augment execution and commercialization of the College's R&D programs.**

*Index Terms* – Engineering education, entrepreneurial engineering, globalization, international education.

## INTRODUCTION

Globalization of the economy is producing significant changes in the engineering profession. The emergence and continued growth of increasingly-capable and increasing-accessible technologists in so-called 'low cost countries' (LCCs) coupled with increasing automation of common engineering functions provides industry with an opportunity to increase the technology content of products and services while reducing reliance on tangible assets in the form of engineering staff and facilities.

These changes tend to divide the engineering profession into two segments. Traditional 'how to do it' engineering focuses on the engineer's role of providing viable products, service, and technologies based on factors such as quality, performance, and cost, i.e., on *technical* viability. The emerging field of entrepreneurial engineering is focused on 'what-to-do', and represents an extension of the engineer's responsibility for viability

to issues such as: what exactly will be developed, who will develop and build it, who will buy it, and how much money can be made, i.e., on establishing *commercial* as well as technical viability [1].

Engineering education must sync up with this evolution of the engineering profession. Marquette University's College of Engineering is augmenting education in traditional 'how-to-do-it' engineering functions with 'what-to-do' *entrepreneurial engineering*, defined as the development and transfer of technology into commercially viable products and services with sustainable competitive advantage in the global market.

The entrepreneurial engineering initiative is embedded in the Masters of Science in Engineering Management jointly offered by the University's Colleges on Engineering and Business Administration [2], and is focused on preparing students to:

- Generate innovative technology-based solutions to existing and emerging global market needs,
- Assess and enhance the global commercial viability of these technology-based solutions,
- Reduce to practice and effectively transfer technology to new products and services,
- Develop global supplier and customer bases to apply these solutions worldwide,
- Maintain the global competitive advantage provided by the technology.

Clearly, globalization is a fundamental element of this initiative. The College's International Engineering Research and Exchange (IERE) initiative [3] is targeted at providing this element. This presentation describes: rationale behind the IERE, activities completed to-date, current focus, next actions, funding and resource considerations, and lessons learned.

## IERE RATIONALE

The primary goals of the IERE are as follows.

- *Create an international learning environment* that is representative of and helps prepare engineering students for participation on global entrepreneurial teams and in the global business environment.

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- *Generate global technology-based business opportunities.* The global entrepreneurial student and faculty teams facilitated by this initiative are expected to produce ‘real’ products and services with the potential to generate new global business opportunities.
- *Establish long-term cooperative research partnerships* with international educational institutions with complementary resources and research programs. Cooperative research facilitated by the IERE is an effective means of leveraging College research and developing the innovations and channels to market that enable commercialization of research and generation of new global business opportunities.

The primary intent of the IERE is to better prepare students for changes in the engineering profession. To better understand the rationale behind the IERE, it is helpful to describe the fundamental value proposition behind the initiative.

Outsourcing and offshoring have become a way of life in industry. The forces that drive this trend in areas such as manufacturing also apply to the development of the technology and the innovations that fuel the global economy. It is asserted here that these forces also apply to university-level education and research.

Conducting research at U.S. educational institutions can be an expensive activity. Expanding research capabilities can be even more difficult given increasingly challenging resource issues. Replacing outmoded research programs with more relevant programs can be still more difficult, with the barriers to exit being as significant as the barriers to entry (e.g. tenure). Similar considerations apply to the initiation and elimination of educational programs and even courses. These are the same forces that stimulate industry to partner with LCC sources. It is asserted here that universities that apply models for education and research equivalent to business models currently being executed by industry can significantly improve the effectiveness of their teaching and research programs.

Given these conditions, the IERE is based on two propositions: 1) entrepreneurial engineering education in a global environment is an important element of a student’s professional preparation; 2) international cooperation is a key element in developing cost-effective means for the College to more aggressively pursue relevant educational and research programs. The situation also implies a third proposition: ideal IERE partner institutions will be located in countries commonly targeted for offshoring by industry, i.e. LCCs.

It is important to note that the IERE is closely linked to the College’s entrepreneurial engineering initiative. This linkage is a motivator for the College’s partner schools to engage in intellectual cooperation. In addition to bringing the College’s technical knowledge and

experience to the cooperative educational and research activities, partnering with the College can provide entrepreneurial knowledge and experience to partner schools. This will be helpful in partner school efforts to commercialize the products of joint development activities, and thus forms a strong motivator for partner school participation in IERE-related activities. (After all, LCCs don’t *want* to be LCCs!)

### ACTIVITIES TO-DATE

The first step in initiating the IERE was selection of a geographical region for seeking partner schools. Obvious choices would be India and Asia, but the first country selected was Poland, for the following reasons:

- Poland is a major target of offshoring by U.S. businesses, thus increasing the opportunity for industrial participation in cooperative research commercialization efforts,
- Poland has a well-developed technical educational system, increasing the probability of forming productive cooperative exchange and research relationships,
- Polish technical universities generally have English language programs, and significant numbers of faculty and students have adequate capabilities in English,
- Poland has a cultural affinity for ‘Western-style entrepreneurship’, thus increasing the probability of success for initial IERE activities,
- Poland has a high unemployment rate (19%), needs to create new jobs in Polish businesses, and generally views the entrepreneurial engineering approach as a viable means of addressing this problem [4].

Poland also has other specific characteristics that made it a good choice for a first IERE venture:

- Marquette University is located in Milwaukee, WI, which has a large and active community of descendants of Polish immigrants, thereby providing a natural support structure for exchange students and faculty,
- The College of Engineering had a strong exchange program with Polish universities in the 1970’s, and some personal linkages remain,
- A number of influential College alumni have ties to Poland, thus increasing the opportunity for industry cooperation and providing a possible funding source.

The first major effort associated with the IERE was a series of five site visits conducted by the author over two weeks in July of 2005 at the largest polytechnic universities in Poland: Gdansk (*ga-dine-sk*), Cracow (*kra-coof*), Poznan (*poze-nine*), Warsaw (*var-sha-va*), and Wroclaw (*vrots-waff*), which have a combined enrollment

of over 120,000 engineering students. (Note: the city is Krakow, the University is Cracow). The purpose of the visits was to test the validity of the initiative rationale and identify potential partner institutions. Interest in the IERE concept was high, and potential cooperative research and educational opportunities were identified at each. Letters of intent to cooperate have been signed with all five institutions.

The author also had the opportunity to accompany Wisconsin Governor James Doyle and representatives of Wisconsin industry on the Governor's trade mission to Central Europe in November, 2005. The purpose of College participation in the mission was to interact with U.S. and Polish businesses participating in the mission to identify and overcome technical hurdles inhibiting international acceptance of products. Such hurdles represent high-potential cooperative research commercialization opportunities for the IERE. Two such opportunities involving the universities in Warsaw and Krakow were identified.

In response to these activities, return visits have been made to Marquette University by faculty from the universities in Wroclaw and Krakow.

A key area of discussions to-date has been the initiation of small projects that generate and clearly demonstrate the ability to cooperate to produce useful results. Establishing this capability is seen as an essential first step toward more ambitious long-range research programs. Specific characteristics of initial cooperative projects include:

- Low or no incremental cost - work already being done or planned by both partners,
- Highly synergistic - don't require significant changes in direction by either partner,
- High probability of success - clear and simple linkages between efforts,
- Make a visible difference - obvious benefit from cooperative efforts.

A similar line of reasoning framed discussions on initiating student and faculty exchange. It seems advisable to start with a limited effort focused on communicating the principles of entrepreneurial engineering at the Polish universities. This will:

- Introduce an important subject area not extensively covered at the Polish universities at this time,
- Stimulate and facilitate cooperative research and commercialization efforts,
- Provide a field of focus for future exchange of students and teachers,
- Give Polish students and teachers an opportunity to experience a class taught by a native English speaker.

This last point is important. Although significant numbers of students at these institutions participate in

English language programs, they often lack self-confidence in communicating with native English speakers. This is a major hurdle to student exchange. The opportunity to experience a course taught by a native English speaker can significantly increase self-confidence, and thereby stimulate interest in participating in the exchange program.

### CURRENT FOCUS

As a result of discussions to-date, three cooperative projects conforming to the criteria outlined above have been initiated.

Dr Andrzej Sobczyk directs the Fluid Power Laboratory at Cracow University of Technology. A particular area of study at Cracow is water-based hydraulics, which provides a green, safe alternative to petroleum-based hydraulic fluids. Unfortunately, several factors limit the replacement of petroleum-based fluids with water, among them being corrosion of the metal components in the system. The College's Fluid Condition Monitoring research program has developed a variety of sensors for industrial application. One of the primary technologies used in these sensors (electrical impedance spectroscopy) has been used extensively to measure corrosion rates in metals. The College has initiated efforts to prototype a real-time on-line corrosion sensor for testing in the Cracow laboratory [5]. In support of the educational opportunities afforded by the IERE, a Marquette student team has submitted a funding proposal to support student involvement in this research [6].

Dr. Konstanty Skalski directs the Rapid Prototyping Laboratory at Warsaw University of Technology. During the author's visit to Warsaw in November, it was noted that researchers there were generating 3-D physical models of bones using CT digital imaging data and the laboratory's rapid prototyping technology. Upon discussions with local orthopedic surgeons, it was determined that such models could be quite beneficial for pre-surgery planning, and also for surgeon training. Warsaw and the College have initiated a project to develop a fast, seamless CT-to-model process for this application [7], and the cooperative research team has recently prepared its first joint publication [8]. In support of the educational opportunities afforded by the IERE, a Marquette student team has submitted a funding proposal to support student involvement in this research [9].

Dr. Irena Chmielewska at Poznan University of Technology is conducting research on speaker recognition. Not surprisingly, speaker recognition algorithms need to account for the native language of the speaker. This researcher has a large database of Polish native speakers, of course, but desires to expand the database to other languages. Milwaukee has a large population of native Spanish speakers, and Marquette's College of Engineering has a speech recognition recording lab. Speech samples are now being collected at

### NEXT ACTIONS

Marquette and posted to the project web site [10] for processing by Poznan researchers.

A potential field of related work involves the development of “electrolarynx” speech prosthetic devices for laryngectomy patients. Research being conducted at Marquette’s Speech and Signal Processing Laboratory would be of direct benefit in specifying and evaluating prosthetic prototypes being developed by Poznan. The use of electrolarynx devices can require laryngectomy patients to re-learn to speak. An additional linkage for this work involves the Speech and Hearing Clinic at Marquette University’s College of Health Sciences Department of Speech Pathology and Audiology. (Coincidentally, this College offers a Bilingual English-Spanish Certificate, which can expedite collection of samples for the cooperative native speaker database development effort.) In support of the educational opportunities afforded by the IERE, a Marquette student team has prototyped a novel electroarynx device that corrects for the monotone output typically generated by commercially-available products [11].

Discussions to-date have also generated an initial faculty exchange activity. In June, 2006, the author will teach a one-week mini-course on ‘Strategic Technology Planning and Development’ at the universities in Warsaw and Poznan. This course is based on a full-semester core course in the Masters of Science in Engineering Management Program at the College [12]. The mini-course consists of twenty hours of lecture and twenty hours of team project work, and provides an introductory overview of the following topics:

- Voice-of-the-customer - how to establish a firm customer-oriented foundation for technology development projects,
- New concept ideation - how to identify breakthrough innovation opportunities,
- Intellectual property generation and protection - how to transfer technology and generate sustainable competitive advantage,
- Technology roadmapping - how to define and communicate the direction and impact of technology development projects,
- Stage gate technology development - how to insure a smooth and efficient flow of the best technology into products and services,
- Integrated strategic technology planning and development - how to integrate the preceding elements into a seamless ‘integrated strategic technology planning and development environment’.

Team project and homework for this course involves the application of these topics to a selected technology area to create a rudimentary ‘technology commercialization prospectus’ that will assess the viability of commercializing the selected technology in a particular application or market.

Regarding next actions on IERE-related cooperative research, the focus will be on:

- Strengthening linkages with the Polish institutions and researchers,
- Identifying additional initial projects with these universities,
- Driving to concrete research deliverables on the current initial projects,
- Developing viable technology commercialization plans for the technologies developed,
- Identifying industry partners for technology transfer,
- Preparing joint publications on the results of these cooperative efforts.

Regarding next steps on the educational element of the IERE, the plan is to establish an ongoing series of mini-courses based on the June, 2006 offering which will rotate among universities involved in IERE activities. The courses will be presented during Marquette’s summer and winter semester breaks, the goal being to offer one-week courses at two universities per break. This activity would include College students traveling to Poland to act as teaching assistants for the mini-courses, and to assist in initiating and coordinating cooperative research projects.

Linkages beyond the five universities initially contacted in July, 2005 are also being pursued. Nicholas Copernicus University in Torun has recently installed facilities to support distance learning. While not a technical university, Torun serves about 40,000 students in a wide range of disciplines. Efforts are underway to determine appropriate IERE-related distance-learning offerings with this institution.

### FUNDING AND RESOURCE CONSIDERATIONS

It should be noted that all IERE-specific activities to-date have been bootstrapped; no significant sources of targeted funding have been used to support these efforts. Based on the acceptance of the IERE approach, a key next activity is the establishment of an IERE funding strategy and the cultivation of significant sources of funding. (The author is open to suggestions). Funds are needed to support the two primary focal points of the IERE - cooperative research and exchange.

Regarding resourcing of cooperative research programs, the next-step plan is to continue with the projects that are already supported at the partner institutions, and seek incremental funding to advance initial efforts beyond current limited objectives. Beyond this, the commercialization potential of the projects will be used to stimulate additional funding by potential technology transfer partners.

As for supporting student, faculty, and researcher exchange, the long-range goal of the IERE is a constant

### LESSONS LEARNED

bi-directional flow of participants. This goal will not be achieved by funding one participant at a time – a more systematic approach and a dependable funding source is required. That being said, initial efforts will continue to focus on relatively short (2-4 week) and inexpensive between-semester teaching and research exchanges (the misalignment between U.S. and European semester schedules can be used to advantage here).

It is anticipated that significant progress on initial activities can be made in the short-run with relatively limited funds and resources. The following are examples of how this is being done.

The ‘Strategic Technology Planning and Development’ course currently being offered in fall and spring semesters through the Engineering Management Program at the College is a project-centric course culminating in a student-generated ‘technology commercialization prospectus’. Student teams in this graduate-level course are assigned technology topics specifically associated with IERE-related cooperative research efforts. Thus, student project work provides exactly the type of international entrepreneurial experience that is an essential part of the College’s overall entrepreneurial engineering initiative. Utilization of this “free resource” also adds an element to the cooperative research activities that can significantly enhance commercialization potential.

All College undergraduate engineers are required to take a senior design course in which student teams select new products to design and prototype. Student teams are being encouraged to choose projects related to IERE-related cooperative research activities. Again, the international element of these activities will significantly enhance the relevance of this experience for these students, and will contribute directly to research efforts. (The electrolarynx prototype referenced above was developed by a senior design student team).

Other currently-available internal resources can enhance IERE-related efforts. Marquette University sponsors annual internal competitions such as the University’s Kohler Center for Entrepreneurship [13] business plan competition. The Golden Angels Network, associated with Marquette University’s Kohler Center for Entrepreneurship is an angel investor group that supports Marquette student, faculty, and alumni new venture mentoring and financing. These programs provide additional funding sources that can augment IERE-related commercialization efforts.

The National Collegiate Inventors and Innovators Alliance (NCIIA) sponsors entrepreneurial teams (E-Teams) and competitions (e.g. BMEideas) that provide an excellent means of funding initial efforts to commercialize university research. (The two student grant proposals cited above were submitted to the NCIIA). Avenues such as these are also being used to augment the project activities described above.

Readers may find benefit in reviewing some specific lessons learned in initiating activities with the Polish universities. The following comments pertain to the site visits of July, 2005:

- July is the holiday season in Poland, so not all faculty and administrators were available for discussions at these visits.
- All senior leadership positions at these institutions – rectors (presidents) down to deans - are elected (three-year term, two-term limit). This was election year, with September 1 being the start of the new term, so this caused some confusion as to who was responsible for what within these universities.
- There were initially some language barriers encountered, primarily at Cracow, although this no longer provides a major hurdle.
- These were basically all ‘cold calls’ by the College’s representative (the author), with only e-mails and phone calls exchanged with key contacts before the visits. Copies of various documents associated with the entrepreneurial engineering initiative and the IERE were sent ahead to provide context for the visit.

Given these conditions, discussions were nevertheless enthusiastically attended at all institutions, with contacts ranging from faculty researchers up to rectors. Initial and subsequent interactions with these partner institutions have revealed several additional considerations:

- Institutions are large and tend to be conservative and bureaucratic,
- Teaching loads and class sizes are quite high,
- Election of senior leadership positions, can cause convoluted and shifting roles, responsibilities, and spheres of control and influence,
- It can be difficult to determine exactly who needs to be contacted to generate specific program actions and results,
- Since the field of entrepreneurial engineering (a key ingredient of this effort) is new, there is no defined entity within the partner universities to cooperate with, i.e., no ‘Faculty (Department) of Entrepreneurial Engineering’.

In general, it has been found that it can be difficult to establish and maintain robust communications links with key individuals even after they have been identified - a situation not peculiar to these Polish universities. But experience shows that once these barriers begin to be broken down, the benefits anticipated by the IERE can be realized, and substantive progress on cooperative efforts can be made - again, a not uncommon experience when establishing ‘local’ cooperative efforts. In other words,

## REFERENCES

in many regards working with Polish universities is a lot like working with U.S. universities.

## CONCLUSION

IERE-related activities can be summarized as follows:

- A rationale for the IERE based on changes in the engineering profession has been established and verified,
- Site visits to Poland have been conducted and initial partner universities have been identified,
- Initial cooperative projects with Warsaw, Cracow, and Poznan have been established,
- Student involvement in research has been initiated,
- An initial educational exchange activity involving these three universities has been scheduled,
- A variety of available resources are being applied to support next actions,
- A long-term funding strategy is being developed.

In addition to these specific items, a more general benefit has been derived: IERE participants have expanded their knowledge, skills, and experience in establishing systematic, long-term international engineering research and exchange partnerships.

In conclusion, initial site visits and follow-through activities have been successful from the perspective of creating a base communication network and establishing initial cooperative efforts. But it should be noted that the complicating factors cited above are still at work, and that robust, sustainable communication linkages are not fully formed. Further, stable, substantive funding for future actions has not yet been secured. While initial results are encouraging, failure to rapidly and firmly establish communication linkages and funding sources pose significant threats to sustaining IERE research and educational activities. Interested parties can follow the progress of the IERE at the initiative web site [3].

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