

Fostering International Partnerships to Enhance Engineering Education and Research: Case Studies on Effective Relationships

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Abstract - This paper presents three case studies of international partnerships – between the U.S. and Germany, Indonesia, and China and India – established to enhance engineering education and research. Each case will examine why these partnerships were established, how they were established, implementation issues, as well as the benefits involved in working with international organizations.

Index Terms – Case Studies, Engineering Education, Industry- Education Relationships, International Partnerships

Introduction: International Partnerships in Engineering Education

From the National Science Foundation to the American Society for Engineering Education to Engineers Without Borders to National Academy of Engineering, numerous educational, governmental, business, and not-for-profit organizations and associations in the U.S. and abroad have called for a more thoughtful, intentional, and explicit internationalization of the curriculum. For example, the report Educating the Engineer of 2020, Phase II, from the National Academy of Engineering, recommends to ensure effective engineering education within the context of a comprehensive examination of all relevant aspects of interrelated systems you need to include engineering practice, a K-12 feeder system, and the global economic system [1]. Internationalization is all the more significant in professional disciplines such as engineering, since business and industry partners increasingly operate in an interconnected, globally-oriented environment. Thus, the need to equip present and future students and faculty with cross-cultural, internationally focused competencies and experiences has never been greater.

Indeed, there exist many opportunities to internationalize the preparation of emerging engineers and other related professionals. International partnership can foster globalization within a specific course or program, or across the entire undergraduate or graduate curriculum. Specific pedagogies that support internationalization include, but are not limited to, study abroad courses, internship exchange programs, student and faculty exchanges, research partnerships, and cultural and language courses, among others. A global mindset also extends to the domains of research and service, as solving complex problems and serving pluralistic societies requires individuals and institutions to adopt a broader worldview, literally and figuratively [2, 3, 4, 5, and 6].

While it is often easy to articulate the need for international partnerships, and to provide broad examples of international endeavors, it is often more difficult to coordinate and implement the specifics in creating and sustaining such partnerships. The case studies highlighted in this paper describe partnerships between U.S. faculty and institutions and those of partners in Germany, Indonesia, China, and India. Each partnership is unique, but represents important strategic initiatives in engineering education: *experiential learning* and *undergraduate research* (Germany); *service learning* and *civic engagement* (Indonesia); and *student recruitment* and *retention* (China and India).

Partnering for Experiential Learning and Undergraduate Research: U.S. and Germany

This example provides a discussion of experiential learning and undergraduate research efforts that have been directly supported, enhanced, and advanced because of international partnerships between the U.S. and Germany.

Some of the U.S. German partnerships developed over a long period of time while others have more recently been

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established. In addition, there are partnerships for graduate and undergraduate internships, undergraduate research, faculty exchange, teaching and research, in addition to partnerships with businesses, industries, municipalities and universities to support a study abroad program about sustainability, globalization, and German culture titled, GO GREEN- Green Organizations: Global Responsibility for Environmental and Economic Necessity.

Experiential learning and undergraduate research are key elements in the GO GREEN program. Students are exposed to the 'best practices' of sustainable development first hand by visiting variety of businesses, industries and municipalities in Germany during the one week study abroad course. The students also are exposed to case studies of U.S. and other EU and German best practices.

Germany is recognized as a leader in the area of sustainable practices – even within the European Union (EU) – and has been actively engaged in instituting environmental policies for over thirty years. Germany has nearly 200 legal acts, which cover all areas of the environment. As part of the EU, Germany is a leader in economic sustainable development and practices in business and industry. In fact, Germany and The Netherlands both have been credited with using new methods and tools to strengthen their government's policies and regulations aimed at improving environmental performance in industry and products. These countries' governments have played a leading role in decreasing greenhouse gas emissions, increasing water and energy efficiency, developing renewable energy resources, and eliminating waste and/or resource recovery. For example, eliminating waste and conserving water and energy are common sustainable practices in all German industries and because of these practices German industries have realized new innovative technologies while working towards these sustainable goals.

The study abroad course uses a diverse selection of businesses and industries. As of this article, the GO GREEN industry, academic, and municipal partners are Berufsakademie Mannheim, Daimler/Chrysler (Rastatt), BASF (Ludwigshafen), ABB (Ladenburg), MVV Energie (Mannheim), Freudenberg (Weinheim), Fraunhofer Institute for Solar Energy Systems (Freiburg), Solar-Fabrik (Freiburg), and the city of Freiburg, University of Applied Science Magdeburg, the town of Ladenburg, Bayer (Leverkusen), Bodensee Wasserversorgung (Stuttgart), Roche Diagnosis (Indianapolis), Interface (Atlanta). Many of these partners were acquired through the school's long time partnership with the Berufsakademie Mannheim. Some were obtained through networking at international and national conferences or through other acquaintances.

A key strength of the GO GREEN course has been to have, from the very beginning, a capable and well-networked academic institution – Berufsakademie Mannheim – to facilitate the identification and connection with industrial partners in the host country (Germany).

The GO GREEN course would not be possible without the German and U.S. industry, municipal and academic partners. These partnerships were initially formed through introductions by the Berufsakademie Mannheim faculty or through networking and meetings with individual parties [7]. There are no formal memorandums of understanding (MOU) or contracts with any of these industrial or municipal partners. The only MOU are with our academic German partners. Only a simple understanding of friendship and willingness to work with GO GREEN faculty in teaching students about sustainable practices and processes at their facility or location exists between the other partners. However, there is a fair amount of communication between partners during the year. We have a very diverse group of industries, municipal, and academic enterprises. Not all of these entities can be visited each year; roughly 5 to 6 are used annually. Our future goal is to offer GO GREEN several times a year, therefore, we are always looking to add additional partners.

Each year, a report of the summary GO GREEN project activities is sent to each partner. It includes a list of course related papers, books, presentations, and projects authored, co-authored or presented by faculty and students. It also includes course related undergraduate sustainable research projects, service learning projects, grants & contracts, and other related international activities related to GO GREEN activities. The booklet contains course related information, student comments taken from student papers and other pertinent information. The goal is to keep our partners informed of the outcomes from their efforts in this endeavor. This report is used as a "thank you" to the participants in helping us educate our students.

Partnering for Service Learning and Civic Engagement: U.S. and Indonesia

This example provides an overview of strategies applied to educational programs in Indonesia. In particular it reviews the partnership developed between the Design Technology Program at IUPUI and the School of Architecture and Planning at Gadjah Mada University in Jogjakarta (Jogja) Indonesia. This program have been in partnership for 4 years and the educational activities within have been framed under the Global Design Studio collaborative.

This was a partnership borne out of a desire to connect with South East Asian colleagues and, in particular, a large post-secondary institute within the world's largest archipelagic state. Indonesia is the world's fourth largest country and the most populous Muslim-majority nation. Forming a lasting relationship with this country and Gadjah Mada University (UGM) provides access to this differing part of the world, climate and culture and a host of research and collaborative educational opportunities. The Architectural and Planning Department at UGM is also prestigious and of a size that was hoped to engender lasting relationships.

The Design Technology Program at IUPUI includes the disciplines of Interior Design and Architectural Technology

and students in these disciplines combine to take courses in residential and commercial construction. These two courses have been used as the platform to launch the international collaboration with UGM and focus on architectural projects that teams of students work on over the course of a semester. These educational activities are housed and delivered under the umbrella organization of Global Design Studio.

Global Design Studio (GDS) is the business model used to format, organize and administer these international student activities. It has proven to be a successful model to maintain and achieve the overarching mission and objectives of the collaboration. GDS houses the templates of agreement between these (and other) institutions (there are several other countries/institutions involved in GDS) as well as templates used to frame the projects and activities. Common logos, drawing formats and project documentation has resulted in an effective organizational scheme that would otherwise be difficult to manage. GDS also promotes the professional nature of the working environment, with students receiving GDS business cards on their first day of class whereupon they are immediately hired and contracted out as project managers for each semester's scope of work.

Partnering with a country as distant as Indonesia does provide unique challenges. However, the challenges have led to the development of strategies needed to surmount these. One of the more difficult problems has been maintaining effective communication with a country that has notoriously slow band widths and frequent interruptions to email service. Perhaps fortunately, the time difference of 24 hours enables communication in the evening and mornings and allows for planning stages either prior to or after a full day of classes. The time difference also allows for several hours to absorb incoming information and enables the students to connect with their partners prior to coming to class. Direct communication using *Skype* software has proven to be the most effective communication tool for the organizers of the program as it is inexpensive and immediate. *Polycom* video and audio communication has also been used, yet often the video is not needed and clear conversation through *Skype* is more than suffice. Video conferencing has not been used as the facilities in Indonesia are not available (or have proven to be too slow), however *Macromedia Breeze* has been explored and will be examined as a means of communication in the near future.

Equally successful has been a web site (<http://www.archstudio.ft.ugm.ac.id/>) that has served as a repository of current work and projects completed in previous semesters. This has been extremely helpful for the students as they can review past and present design solutions to problems and see how others solved similar problems to their current project. It also has been a valuable marketing tool and has helped to advertise the activities undertaken through this collaborative venture.

Perhaps the most unique developments in this partnership have arisen from the multiple natural disasters (e.g., tsunamis and earthquakes) that have recently plagued Indonesia.

Although horrific and devastating, these disasters have strengthened the relationship between these universities as it has led to a common ground of support and a rich resource for service learning directed at disaster reconstruction. A concerted effort has been made to aid the Indonesians, yet a similar effort has been made to treat these experiences as fertile learning experiences for the students, and opportunities for them to see how entire communities face rebuilding their lives. This has led the development of projects that have, over the years, strayed away from fictitious design problems to real ones that are directed at the homeless rather than the privileged. Following from this has also been disaster relief work directed at the southern United States that has seen both American and Indonesian students designing new dwellings for those affected by Hurricane Katrina. These types of projects had led to lively discussions about cultural approaches to urban design rather than a focus upon the design of single dwellings.

Another key ingredient to the success of this program is it's built in flexibility. Institutions that have tried to join GDS, but who are not flexible in their curriculum and pedagogy, have found the loose and real-time structure of GDS too difficult to manage. However, IUPUI and Gadjah Mada have picked up the various projects at the level that proves to be most effective for their current educational needs, and have entered and exited projects as they see fit. The design continuum (the movement from schematic stages to construction document phases) provides the structure for participants and allows them to see where they can best align themselves with a project. Gadjah Mada students, for example, may enter the project at the schematic stage and leave their conceptual designs for IUPUI students to take into design development stages. This has proven to be an effective method of encouraging other courses and disciplines to enter the program. An example of this would be a Mechanical Engineering Program that uses GDS pre-designed building shells to design HVAC equipment and learn about duct routing.

Imperative to the future success of this program is the maintenance of the web site and more direct interaction amongst the students. The differences in semester schedules has proven to be difficult to keeping design projects on track and developing a sense of urgency with respect to deadlines that differ between institutions. Flexibility is paramount to the success of GDS and programs similar to these.

Assessment and reflective activities need to be more fully incorporated into the structure of this collaboration to determine how to mend its broken parts. Constructive critical comments and reflective assignments need to be included as exit surveys at the end of each term in order to detect the faults of GDS and allow it to grow in a direction that would benefit students. Recognized as a significant problem in the beginning was the distance and consequent cost of physically getting more students to travel to distant Indonesia. The recent political, terrorist activities and natural disasters have also made it difficult for students to travel to this country as well. To date, only a few have been able to go, and through

this we have learned that it is imperative to video and record not only the sites of projects and neighboring architecture but also to capture conversations with key informants and to document building practices in situ. This has led to an outgrowth of undergraduate research tied to GDS that has inspired more senior students to take part in this organization. Partnering with IUPUI's local Engineers Without Borders Chapter has also enabled students to hear more about international collaborations that have made significant and real changes in the world. It is within these contacts with real people and sites across the globe that the heart of this collaboration lies. Therein lays the value of our efforts as educators.

Partnering for Recruitment and Retention: U.S. and China and India

This example provides a discussion of recruiting activities and partnerships between the University of Louisville and locations in China and India. Research productivity of the universities depends, to a great extent, on the capacity of the graduate students to perform the required research and other scholarly tasks for funded projects. Historically, the majority of graduate students in American higher learning institutions have been foreign born and from Latin and central America, Far East, and Western Europe.

Not many American born students find it interesting to pursue beyond B.S. level of education. The authors believe the primary reason for American born students not being interested in pursuing a Ph.D. degree is cultural. Higher education and pursuit of a terminal degree is valued much more in the eastern culture than it is in the U.S. The availability of well paying jobs for the U.S. born graduate engineers with a B.S., M.S., or M.Eng. is another factor enticing students to enter the work force upon graduation rather than enrolling in a Ph.D. program. Many believe that holding a doctorate degree (even in an engineering field) limits one's employment opportunity. Many also see the pool of available jobs shrinking to just university positions or jobs in research laboratories or research agencies. Even-though this situation is changing, the authors believe that there are still big opportunities for Ph.D.'s in the job market not only in the U.S. but even in the developing countries. The U.S. universities have generally depended on the non-U.S. born students to perform their committed research and create the ever-increasing expectations of number of Ph.D. graduates.

At the same time, because of the tremendous recent growth in China's economy, colleges and universities in China try to capture the talent of their youth encouraging them to remain in China for their Ph.D. degrees. Chinese students have been responding to this new sense of urgency declared by the Chinese government and the universities. Many who would have otherwise left for further education in the U.S. have chosen to remain in their motherland and pursue terminal degrees in China. India on the other hand has left their young and aspiring students almost untouched leaving their destiny to themselves, thus creating another pool of young capable graduate students to fulfill this need. Other countries such as

Australia, which historically had a limited access system of higher learning, have started to actively recruit students from China and India. The students have responded well and many have chosen to go to Australia, Poland, and Germany instead of going to America. It is cheaper and also closer to their home country and the education level seems to be equal if not somewhat superior. In India many graduates of Indian Universities have traditionally stayed in India for their advanced degrees due to the available facilities before going abroad for doctoral or post-doctoral studies. There is a change in trend due to the newly created high tech jobs which lures them to remain in their country also to not consider pursuing a Ph.D. degree. India, however, remains a prime searching ground for students by U.S. universities. Some India students have always sought to pursue their careers in the U.S. industries with their Master's degree and not helped the U.S. university pool of available graduate students.

The situation described above has created a shortage of graduate students in U.S. universities while the American students remain disinterested and the majority continues to ignore the advice of the faculty. In 2005, most universities reported a drop in the number of graduate applications they had received compared to the prior two years. It has become evident that the attitude of waiting for applications to come in and expect the students to be loyal to the first university that grants them admission and scholarship does not work. Each qualified student has many choices. They take their time to pick the best offer, which may not be the one offered by your institution. The whole scenario has added further dilemma to the U.S. faculty to pursue their research efforts on one hand and to their administration on the other hand by helping them with more graduate students for carrying out the research work with them.

Recognizing that competition for graduate students is very fierce, the authors concluded that an aggressive and proactive approach is necessary if the Ph.D. program at their institutions is to show growth and success. Although they had pursued this shortage with their own contacts in China and India earlier, the two faculty members from the University of Louisville's Civil Engineering Department decided to travel to China and India.

During fall 2005, a recruiting trip to China was arranged. Due to other responsibilities, the duration of the trip was limited to 8 days. In order to make this trip successful, extended pre-planning was done with the help of current Chinese faculty and graduate students. Out of six universities targeted, four were selected to be visited. There was a connection to each of these institutions, either through faculty or current graduate students. A contact person was identified at each of the universities and was contacted through email. In most cases, the contact requested more information regarding the technical background of the author so they could identify the most suited faculty member to serve as liaison and as the host of the visitor.

Generally, two presentations were made during the visit to these institutions. One was the technical presentation

highlighting his area of research and the other a general introduction of his university and areas of specialties of the department faculty and students along with the presentation on the Ph.D. opportunities in terms of fellowship, research and teaching support opportunities (at the University of Louisville). The four universities chosen for the visit were spread around China with two on the east coast and the other two in the central provinces. In order to complete the visit in 8 days, travel by air to the interior regions was necessary and only two days could be devoted to each university including travel time. The final list of universities included: Tongji University in Shanghai, Southeast University in Nanjing, Chongqing University in the Sichuan province and Hunan University in the Hunan province. There was a two to three hour flying time between each site except for Shanghai to Nanjing, which was a three and a half hour train ride. The author traveled alone without a translator; however, this did not pose any problems or complications since the hosts at each university were gracious enough to provide an escort to meet the author at each airport or train station. All accommodations were arranged by the hosts usually at a hotel either on the university grounds or a nearby property. Even though there were some variations at each location, generally each visit consisted of a technical presentation during which anywhere from 35 to 90 students and several faculty members were present.

There was usually a special and more intimate session with a smaller group of very interested and highly motivated graduate students who wanted to know the application process, exact admissions criteria, the number of Ph.D. students accepted to the program each year, the number and size of Fellowships available, and the estimated time in which degree requirements could be completed. It was during these small group discussions when it became clear to the author that one of the major impediments for the students is the GRE requirement. They feel that it takes about a year to prepare for the GRE, which they are willing to invest, in order to properly prepare for this exam. The problem, however, is that they feel that during undergraduate years they have the time to do so, but at that time they do not have a compelling reason to do so. The necessity of taking the GRE and the importance of doing well on the exam becomes apparent to them once they are in graduate school. That is usually the time when they begin to seriously consider options for pursuing a Ph.D. degree. They find it very difficult to devote time to preparing for the GRE during the graduate year.

Each university visited, also arranged a tour of the laboratory facilities. The author was highly impressed with lab equipment and facilities. Almost at all locations a lot of activities were observed in each lab indicating the high level of research that is conducted at each university. The testing equipment, in the opinion of the author, was in line with what is available at top universities in the U.S. The students have excellent educational opportunities in China should they decide to stay. However, it should be noted that despite such opportunities at home, the Chinese graduate students

prefer to go abroad and especially the U.S. for their advanced education.

The presentation of the earlier paper by the authors in the international education meeting in Sharjah in April 2006, led to successful recruiting efforts, when one university offered to provide four doctoral students in civil engineering with all their expenses borne by their country. They see this as an excellent opportunity for global cooperation to the efforts of the authors to help change the U.S. outlook towards the global picture of graduate education and also to exchange program of faculty as well in the future.

One of the benefits of international relationship is the exchange of scholars however; the Chinese nationals have had a very difficult time receiving U.S. visas. An assistant professor from Hunan University was successful in receiving a fellowship from the government of China to visit Louisville to collaborate with colleagues at the University of Louisville. However, after three unsuccessful visits to the U.S. consulate in Beijing to secure an entry visa to the United States, he gave up and decided not to pursue this any further. Unfortunately, this was not an isolated case and rejecting visa requests especially in the case of Chinese nationals is not uncommon. For those who do receive a visa, such visits prove to be highly beneficial. Most of the visiting scholars spend some of their time improving their language skills. Some manage to co-write a technical paper before returning to China. Thus, it is definitely worthwhile and even necessary to establish an on-going relationship with selected universities in the Latin America, the Far and Middle East or Eastern Europe to secure a steady flow of qualified Ph.D. applicants. Visits to selected universities compatible with your program will pay huge dividends if it is planned ahead of time and a positive exchange of students as well as faculty relationship is established.

Conclusion: Issues for Consideration and Implementation

Although each case is unique in its origins and development, all three have the following five characteristics in common: (1) Interest on the part of individual faculty members; (2) Willing institutional climate that supports international partnerships; (3) Receptivity on the part of international partners; (4) Discipline and dedication to making partnerships sustainable; and (5) Recognition that international activities connect to, and effectively expand upon, existing higher education priorities.

Interest on the part of individual faculty members

Faculty in higher education are, in essence, the ultimate knowledge worker. Most operate with a tremendous degree of autonomy, are well educated, and often engage in highly specialized professional practice. All of the U.S.-based faculty in the three case examples profiled demonstrated a tremendous interest in initiating, developing, implementing, and, ultimately, maintaining international partnerships. Thus, institutions seeking to enhance their international

portfolio are encouraged to elicit support from individual faculty members who have an interest in, a passion for, and a desire to collaborate in a global context.

Willing institutional climate that supports international partnerships

Closely tied to individual faculty interest is a willing institutional climate that supports international partnerships. This begins by an explicit and intentional expression on the part of senior administrators on the importance of such efforts, and how internationalization is aligned with the strategic directions of the institution. Beyond mere lip service, however, is the allocation of resources – financial and other – to support international efforts of faculty and students. Finally, appropriate reward and recognition of faculty efforts in this area are important considerations if such ongoing efforts are to become institutionalized practice.

Receptivity on the part of international partners

It is likely understood that in order for international partnerships to work, the international partner must be a willing participant. Despite the seemingly obvious sentiment, it is important to recognize that the relationships highlighted in each case above demonstrate not a one way street but a true partnership between the U.S. and their international counterparts. Recognizing partner needs, wants, resources, limitations, and constraints can go a long way toward launching successful partnerships.

Discipline and dedication to making partnerships sustainable

Most international efforts that make a difference in the long-term are not one time interventions. Instead, discipline and dedication – from individual faculty, institutions, and partners – to making partnerships sustainable must occur. Figuring out how to marshal resources, overcome resistance, work through challenges, evaluate and improve processes, disseminate results to others, and expand the partnership are all ways to strengthen the sustainability of international efforts.

Recognition those international efforts connect to, and effectively expand upon, existing higher education priorities

Finally, and perhaps most saliently, it is easy to point to international efforts as “something new” that faculty and institutions are doing. While many of the efforts highlighted in the cases above are, indeed, innovative, at their core they each connect to, and effectively expand upon, existing higher education priorities. These include *experiential learning* and *undergraduate research* (Germany); *service learning* and *civic engagement* (Indonesia); and *student recruitment* and *retention* (China and India). Thoughtful recognition of the ways that internationalization can organically evolve from existing institutional activities can help to garner support for such efforts. Indeed, institutions with successful strategies and best practices can often take these initiatives “to the next

level” by extending their good work beyond their immediate setting. As this paper has profiled, there are plenty of challenges, opportunities, and rewards for students, faculty, institutions, and partners when international activities are supported.

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