# 2006-1098: INTERNATIONAL SERVICE ENGINEERING ACROSS ACADEMIC BORDERS

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# International Service Engineering Across Academic Borders

## Motivation

The National Academy of Engineering's recent report, *The Engineer of 2020*[1], clearly spells out the challenges and opportunities confronting the profession, and future engineering graduates in particular: globalization, sustainability, complexity, and adaptability. Coupled with this vision is the reality of program accreditation criteria. Among the oft-cited ABET criteria[2], *h* (broad education), *i* (life-long learning), and *j* (contemporary issues) are widely recognized as especially challenging to successfully integrate throughout the engineering curricula and to assess. Programmatic responses to such stimuli are slow, even at the most nimble universities. Globalization requires engineering students to be educated differently. Whether it be the practical job-related skills expressed by ABET, the broader experiences suggested by the NAE, or the cultural shortcomings lamented by best-selling authors[3], it is clear that engineers must receive an international education. Most academics understand this. The challenge then is how to enrich engineering programs while not abandoning the substantial body of knowledge needed.

## Background

This paper introduces the international education strategy implemented in the Michigan Tech Department of Civil and Environmental Engineering. Program objectives, designs and outcomes are presented. The strategy has several key tenets:

1. Flexibility
2. Multiple opportunities
3. Voluntary
4. Service-based

A rigid program structure would greatly reduce enrollment in such programs. While many students understand the value of international experience, pragmatism often takes priority. Practical experience is important, financial burdens are real. International programs must therefore allow the students to pursue traditional co-ops or internships, and to finish their degree programs as expediently as possible. Finally, while developed by faculty within one department, the strategy is one where students from any engineering department can participate at any year of study – student development across academic borders.

The Michigan Technological University (Michigan Tech) Civil and Environmental Engineering Department has created four distinct programs to target students who are looking for one international experience, or those who want to assemble a multi-year sequence of experiences. While it is clear that more experiences results in richer learning,

the strategy has to accommodate those who try and decide other paths are a better match for their interests.

In a world where professors called all the shots, a mandatory international experience might seem like a positive program design feature. Reality conspires against this utopia – student time, interests, and finances are all real limitations, in addition to the occasional student with an insular world-view. There are benefits of keeping such programs voluntary: students in such programs are motivated and excited, there is some self-worth reward for students who opt into such programs (rather than having been forced into one), and an organic *esprit de corps* grows among the programs' participants.

Having service-based international programs makes sense, particularly for environmental and civil engineering. Students often join these majors out of an interest to help the public. The students have innumerable skills to assist communities globally, and it is clear that the combination of international settings with service is strongly attractive to female students.

**Methods and Outcomes**

Michigan Tech's Civil and Environmental Engineering Department has created an international engineering education strategy with four main programs. The programs can be used as scaffolding to deeper understanding of international development engineering, or taken independently. The four programs are:

1. Engineers Without Borders
2. International Senior Design
3. Minor in International Sustainable Development
4. Master's International Peace Corps

*Engineers Without Borders*

Present in a growing number of campuses nationally (90% growth rate in 2005 has resulted in 100 university chapters at present), Engineers Without Borders is a non-profit group which focuses on international engineering service projects, mainly in developing nations. Operationally, the key advantage of a student chapter is being able to leverage the information network provided from the reputation of the organization. Understanding the nuances of finding, funding, building and maintaining projects in developing counties is possible through interactions with existing chapters, attending EWB national conferences, and using EWB website resources. These are not minor challenges. Programmatic advantages of having an EWB chapter serve as one key component in an overall strategy include the involvement of any student by year or major. The Michigan Tech chapter, for example, has grown to over 75 active members within one year and includes first-year undergraduates through doctoral students in thirteen majors (eight engineering, five non-engineering). Approximately 40% of its members are women.

A critical role that EWB plays in the Michigan Tech Civil and Environmental Engineering Department international engineering strategy is cultivating a sense of service among the students. In fact, faculty mentors have commented on how the Michigan Tech EWB chapter is a showcase of student activism, passion, and service (externally verified by the chapter receiving the EWB National Chapter Development Award after its first year). In this one case, at least, it is an example of "if you build it, they will come." This organization seems to be a venue for students who could not otherwise work on such international projects in a sustained collaborative environment. In many ways, the EWB chapter serves as the foundation for the international strategy in the department: its multi-year nature allows a sense of community to flourish, projects are collaborative, and the service mindset propels students to seek other opportunities.

The Michigan Tech EWB chapter has recently finished its first implementation project at an elementary school in Santa Cruz, Bolivia. After months of design, fund-raising (about $15,000) and planning, a team of nine worked with the local community members over a ten day period to construct a latrine building, septic tank, and drain field. For the EWB members, the support, enthusiasm and gratefulness of the community created instant understanding for the power of international engineering service. Sharing these experiences is infectious among the students. Promotion of such international programs is best left to them. Based on the successes of this project, the chapter is currently working with a community in Guatemala, this time further up the design sequence. In Guatemala, the EWB team will be involved in the community assessment to collaboratively build a list of engineering needs. From this list projects will be designed and built over the coming years with the intent of creating a long-standing relationship with the community.

*International Senior Design*

This program began roughly five years ago, the vision of a lecturer in the department. To integrate her consulting career and volunteer experiences with non-governmental organizations, the department created a senior design section that required the students to execute a project in a developing country. This led the first groups to Bolivia with later groups going to the Dominican Republic. Enrollment in the international senior design groups is limited to twelve, partly for educational purposes, partly for travel purposes. The two-semester course flow requires the project teams (3-4 students) to prepare for their two weeks in country by first reviewing the design of a project from one of the previous year's teams. The student teams will be responsible for the construction of one of those projects then gather field data (e.g. surveying, water quality measurements, etc.) for the design of new projects. The design work is completed upon return to campus. With this program design, the in country construction work is completed early in the two semester (summer and fall) sequence. Among other things, this provides ample motivation for the students to work hard on the design of their new projects upon return to campus. Considerable preparation is required for travel, safety, and cultural education prior to departure, as this program attracts many students who want to have a meaningful but brief sampling of work in a developing country. This program too is attractive to women; about 55% of the 110 students involved to date are female (one group of twelve last year had eight women). Participation in this program requires some financial

planning by the students, as it accounts for six course credits (about $1500 in tuition at Michigan Tech) plus a fee of nearly $1500 to cover travel costs. In comparison, the out-of-pocket expenses for EWB members run around $500, the difference offset by fund-raising. The cost barrier certainly precludes involvement by some students, but likewise the students who participate have real (and metaphorical) buy-in to the project. Project time in country is critical so it is imperative that all students be focused on work, not play; attitude is critical to team success. Departmental fund-raising targeting international program participation could also defray some of these student-borne expenses. The Michigan Tech Civil and Environmental Engineering Department has identified its international engineering strategy as one of its key development foci.

*International Sustainable Development Minor*

Following a few years of successful international senior design projects, it was apparent that considerable student interest was present. It was also apparent that traditional engineering education was considerably inadequate in preparing students to understand the non-technical challenges to engineering project design and implementation, particularly in developing nations. A minor degree program in international sustainable development was created to address these issues. Debuting officially in Fall 2006, the minor provides interested students an opportunity to weave learning of social, economic, and cultural issues throughout their engineering education. The program, an additional 24 credits, is depicted in Figure 1 below. The course sequence begins in the first year with a weekly colloquium for all minor participants and culminates in an international senior design project. The goal of this program is to build the student's capacity to collaborate with people of any culture, both domestic and abroad, and the student's appreciation for the non-technical issues that must be addressed in any engineering project.

*Master's International Peace Corps Program*

In existence since 1997 the Master's International Peace Corps (MI PC) program in civil and environmental engineering is a unique collaboration between Michigan Tech and the U.S. Peace Corps[4,5].The program requires one year of academic study on campus, followed by twenty-seven months of Peace Corps training and service, resulting in the thirty credits for the program. Students must have a baccalaureate degree in engineering and demonstrate (or take courses in) Hydrology, Geohydrology, and Water and Wastewater Treatment as adequate technical preparation for typical Peace Corps projects. In addition to five technical electives, the on-campus phase of this program includes two required courses to prepare students to plan and implement projects with communities in developing countries: Field Engineering, and Rural Community Development Planning and Analysis. Students earn seven credits for international field experience over the two years of Peace Corps service (MI PC volunteers are still registered graduate students during service). During service in country, the MI student is required to execute a research project, in addition to their Peace Corps responsibilities, which serves as the basis for their master's report. Upon completion of Peace Corps service, students return to campus to present and defend this research project. To date nearly fifty students have

been in this program, about 37% women. The countries of service to date can be found in Figure 2.

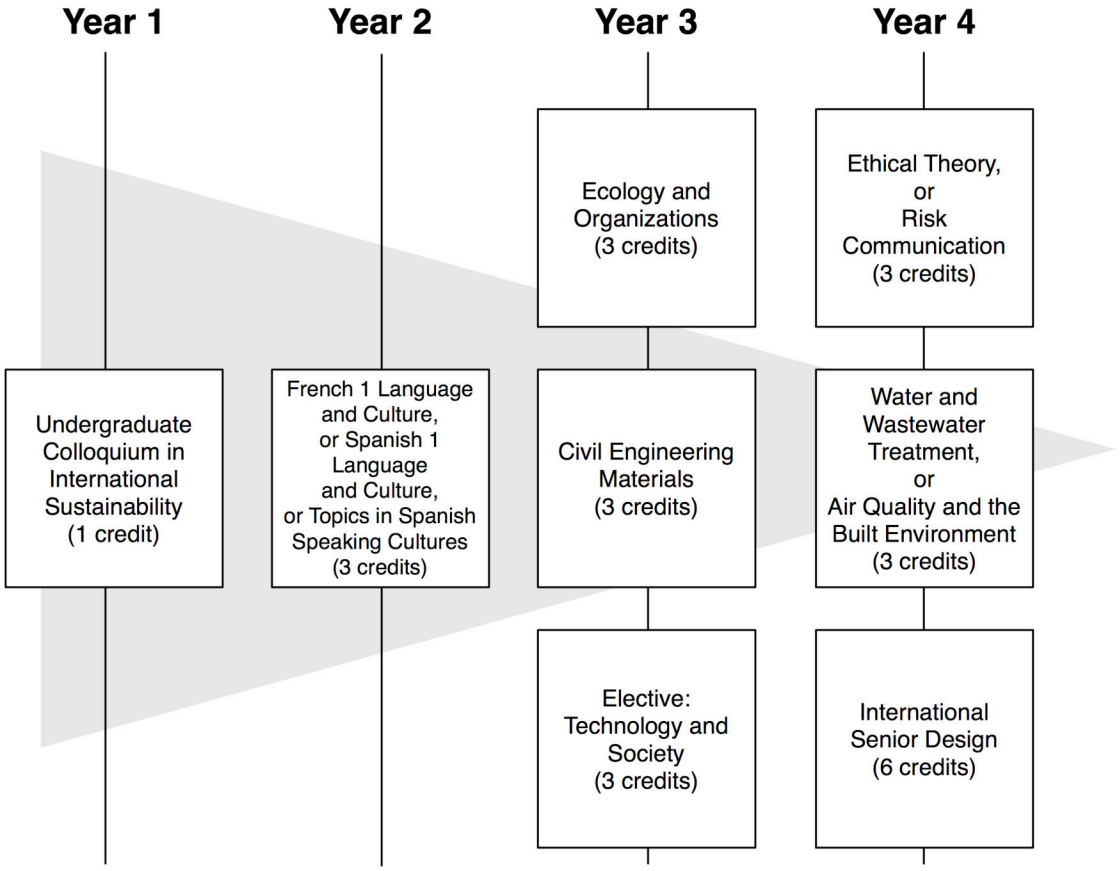


**Figure 1.** Flowchart of the international sustainable development minor at Michigan Tech

*From Programs to Student Development: an International Service Engineering Strategy*

The four programs presented constitute the pillars of the Michigan Tech International Service Engineering Education Strategy in the Civil and Environmental Engineering Department. There are other opportunities (study abroad, for example), which complement this strategy, but as they are offered outside the department have not been officially integrated. Figure 3 shows the strategy in a timeline fashion. Again, note that each of these programs is voluntary. Figure 3 depicts how a determined student could engage in a progression of international programs over a seven-year period. As the programs available to young students (EWB and the Minor) are new, it is too early to tell how these programs will influence participation in other programs. First-year experiences with EWB suggest highly synergistic behavior with the MI program.

While it is evident that participation in one of these programs has an influence on most students' views of the world, it is likely that a student engaged in several of these programs would become a fundamentally different type of engineer. Assessment of such influences has been implemented in all the programs, primarily via a ninety-question

survey before and after participation. Data analysis is currently underway.


**Figure 2.** Nations where Michigan Tech Civil and Environmental Engineering Master's International Peace Corps students have served.

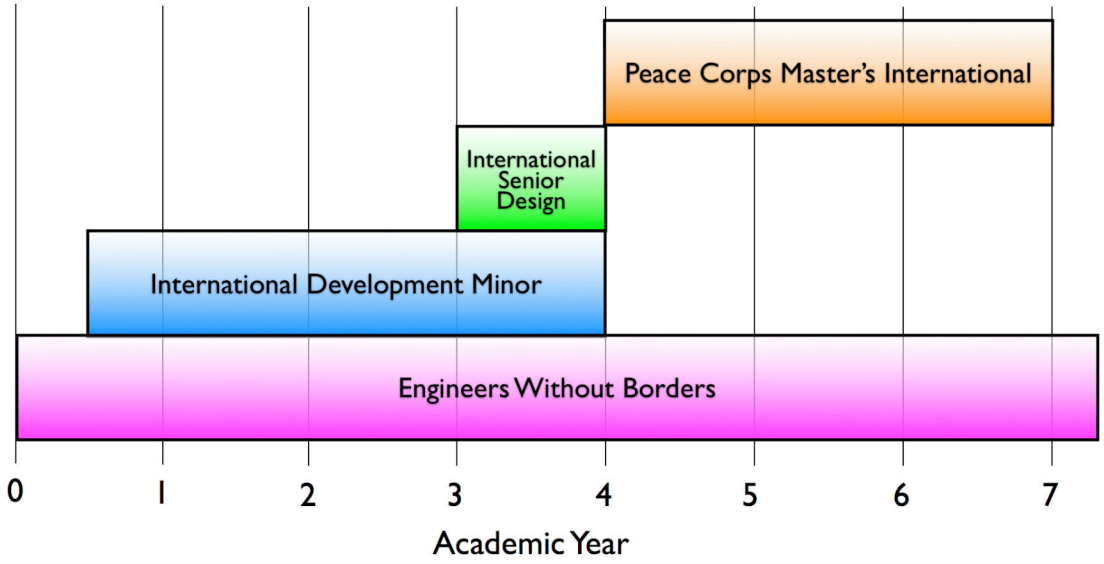


**Figure 3.** Timeline depicting program availability to students in Michigan Tech's Civil and Environmental Engineering Department. Year 0 marks first day on campus as a first-year student.

However, the strategy has been designed for maximum effect should a student be engaged in all four programs. Since retention of knowledge is a major goal of the strategy, its structure should reflect that goal. Kolb identified a cyclic structure that elevates retention among students[6,7,8]:

*Motivation → Theory → Application → Analysis*

While Kolb argues that structuring education along his four-step cycle allows a student to begin learning at any of the four steps, it often makes sense to begin with Motivation. The Motivation establishes the reason for wanting to know more about the topic, its importance, its *Why?* Once the Motivation is evident for most students, learning will flow. The next stage in Kolb's model is the Theory. This is where the science, methodology, and evidence are revealed. It's the *What?* The third phase in the learning cycle is the Application. In this phase, students are asked to put the Theory to use. By doing so, students will better understand *How?* An effective strategy to use in this phase is problem-based learning. The Analysis step is the fourth element in Kolb's cycle. This is the time to encourage students to think of potential complications, implications, connections, and issues by asking *What if?* A simple way to facilitate this is to pose a problem similar to that in the Application phase but with variables or conditions changed.

Figure 4 shows how the Michigan Tech Civil and Environmental Engineering Department international sustainable engineering strategy is designed around the Student Development Spiral; an educational model that should be effective for the range of learning styles among contemporary engineering students[9,10]. EWB, a service-rich volunteer program, creates a powerful motivation among student participants. Students engaged in one project through this group typically develop a thirst for learning more about international development. Learning the fundamentals and the complexities of international service engineering is available through the Minor in International Sustainable Development. With the tools learned via this minor program, students are more adept at applying them to a real project in their International Senior Design. Lastly, students ready to handle the open-ended problems associated with projects in the Peace Corps can pursue research in a challenging international service setting.

**Summary**

At a minimum, these programs have created a significant culture of international engineering scholars within the department. Yet because of the multidisciplinary composition of majors in some of the programs, this culture is now breaching departmental borders. Another evident benefit is the interaction of students across academic levels, first-year students working and discussing international engineering projects with doctoral students, for example. Although the students provide incredible energy to power the programs, faculty leadership is required to make each flourish. This requires faculty and administrators to be visionary, seeing beyond the confines of traditional curricula, and traditional expectations. While preliminary qualitative evidence is promising, time will be needed to see if this strategy results in engineers that can more effectively function in an increasingly flat world.

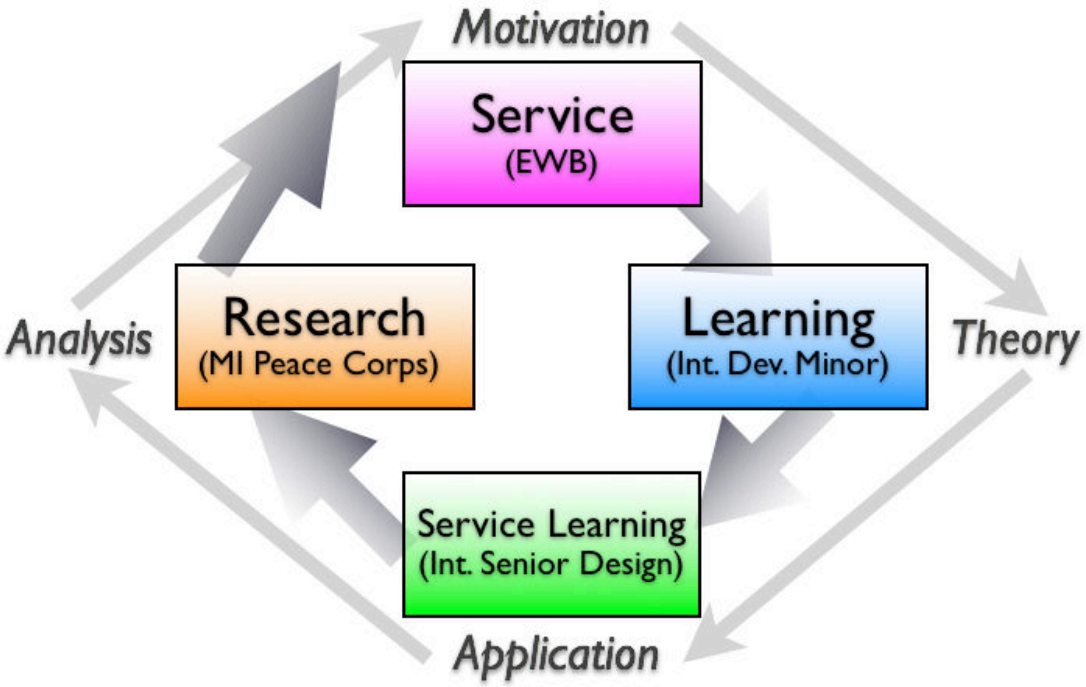


**Figure 4.** The Paterson Student Development Spiral for international service engineering. Based on Kolb's learning cycle, the Michigan Tech strategy provides motivational experience through service in Engineers Without Borders, theory via classroom learning in the International Sustainable Development minor program, application of the theory via service learning in an International Senior Design project, and culmination in analysis of complex research projects in the Master's International Peace Corps program. This student development pathway prepares the graduate for continually higher levels of such activity, in a spiraling pattern of influence and effectiveness.

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