Undergraduate Engineers Get Credit for Saving Venice

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Introduction

Engineering students, like their peers in other areas of study, enter college today with an open mind. They have hopes and dreams, fears and priorities . . . and when students begin their university career, their goals include having an international experience, as well as having real world experience that will someday lead them to a job (1).

Today's students grew up in an increasingly shrinking world, with about half of them having had an international travel experience with their family and nearly all of them having taken a foreign language in their earlier education (1). Somewhere along the way, though, the international experience doesn't seem to fit within the engineering curriculum; there are too many course requirements to complete before graduation; and students drop off from their grander intentions, many even letting go of their hopes of developing a better understanding of a foreign language while at college. The barriers to international engineering study are multidimensional and include student barriers (perceived detraction from progress in the major, financial, language, reluctance to travel), faculty barriers (time away from research, family, reward system), and institutional barriers (curriculum constraints, awarding of credit, academic calendar, academic content).

WPI has found ways to overcome these barriers and has been providing an international experience for its graduates since 1980 – currently more than 50% of each graduating class has an international experience. Our paper will attempt to answer three important questions: What institutional structures make our program work? How do we know the program works? How can significant international experiences work at other engineering schools?

Background

There are many priorities for students, but in a world where America's reach seems to touch every spot on the globe, where *McDonald's*, *Coca Cola* and *The Gap* appear on every street corner from Bangkok to Boston, most engineering students (97%) still complete their education without an international educational experience and with diminished knowledge of their place in the global marketplace as engineers (1). Evidence seems to indicate that students do not have an appreciation of their role as engineers in society, as they are most often not involved in solving real problems that have an immediate impact on the world in which they live. Compounded on top of all that is the

post September 11th reality that we need to produce students in general and future engineers in particular with a better, more realistic picture of the world, its needs, its opinions and its sensitivities.

For many years WPI has tried to find ways to graduate socially conscious, globally literate engineers. We do this by breaking the barriers of traditional course boundaries and rigid curriculum requirements and placing students in international contexts that provide learning opportunities consistent with our mission. We desire student-learning outcomes that are not limited to basic comprehension or simple application, but demonstrate analysis, synthesis, and evaluation (2). Our belief is that global perspective outcomes are best achieved in an international setting rather than just in the classroom or through information technology. Off-campus opportunities provide students the means to move from self-knowledge to understanding complex relationships, and to understanding multiple perspectives and cross-cultural issues (3). But, how do we get from these lofty goals and descriptions to the details of earning academic credit while helping in the preservation of Venice?

The increasing frequency of high tides, the slow sinking of palaces and churches, the incredible impact of 12 million tourists a year - all contribute to the problems of Venice, Italy. Canals designed to handle limited human-powered boat traffic are now inundated by hundreds of powerboats. Biological, chemical, and physical factors damage 500-year-old walls, resulting in annual repair costs of several million euros. *Moto ondoso*, the damage caused by the relentless pounding by boat wakes, is a highly complex problem that involves technology, politics, culture, and economics. The solution has puzzled local officials. Yet, teams of WPI undergraduate students working in Venice have made significant contributions toward the solution while receiving academic credit.

Working for two months in Venice with the *Consorzio Trasportatori*, a team of four engineering and science majors from Worcester Polytechnic Institute optimized the boat cargo delivery system it operates in the Venetian lagoon and canals. The team combined sophisticated geographic information systems, clever data tracking, and carefully cultivated relationships with the individual boat captains in the *Consorzio* to design a system that halves delivery times and the attendant boat traffic, pollution, and canal damage. A follow-up team collected boat wake data, analyzed canal traffic patterns, and developed a procedure for estimating canal wall damage from wake impact. The results of both projects provided the basis for the new cargo boat warehouse and distribution center now under construction in Venice. And each student received academic credit for completing a degree requirement while living and working in Venice.

Instructional Design and Program Structure

Many recent engineering education reform efforts incorporate proven learning strategies like active and cooperative learning (4,5), and project-based learning (6,7). WPI has also utilized these strategies, but what distinguishes our program is that we integrate material that is normally taught in a compartmentalized sequence of fundamental courses. This includes both technical and non-technical (general education) courses. Our instructional

design bridges learning theory with a structure that awards credit for work integrating social science, humanities, and engineering.

Instructional design based upon situated learning theory includes authentic activities, contexts, and assessments. It provides collaborative knowledge construction and opportunities for explicit articulation of knowledge during the learning process (8-10). Authentic learning environments seek to place students in situations that mimic the way knowledge will be used in professional practice. Learners need access to experts, collaborative activities that provide multiple roles, and multiple opportunities to engage material (11-14). Assessments must be employed that are consistent with the instructional design, and are usually performance-based (15,16). Most efforts to provide these elements are focused on upper level courses. Providing them at lower levels of the curriculum can be problematic since the traditional assumption is that students must learn fundamentals before they can successfully attack significant open-ended problems. How can students solve difficult open-ended multidisciplinary problems before they've actually learned some of what they need to know in order to solve them? How can they do this in foreign culture when a significant language barrier exists? The answer lies in proper preparation and project management, and in providing key structural elements that support the academic enterprise.

Each international center is residential. Students travel to the site for a 2-month period, with a resident faculty advisor to conduct the projects. Local government, industry, nonprofit organizations, and sometimes universities sponsor projects. Each sponsor provides a liaison responsible for overseeing student teams working with the agency. A WPI faculty member serves as project center director – responsible for setting up projects, general academic issues, and overseeing center operation. A local coordinator, who is a permanent resident at the site, assists the center director particularly with housing and logistical concerns. Student preparation for the experience includes formal coursework taught by WPI faculty, and orientation/cultural preparation taught by WPI professional staff. The same staff handles health and travel issues, risk management, and re-entry issues. At the completion of a project, each student team submits a substantial written report to the sponsoring agency and the faculty advisor. In addition, a formal presentation is made to the agency before the students leave the site.

Evaluation of Learning Outcomes

The unique nature of our program requires the application of good assessment practices to understand what works and what needs improvement. Our major evaluation tool for student outcomes is that all reports submitted for grades during a calendar year (nearly 200) are read each summer and evaluated by a trained team of paid faculty reviewers. This practice was established several years ago and it consistently yields results documenting multi-dimensional student learning (17).

Our evaluation covers everything from project objectives, quality of the literature review, application of appropriate methodologies, findings and analysis of data, achievement of educational goals, quality of the writing and presentation, and several EC 2000 outcomes.

Projects completed at our international centers continually outrank projects done on campus by a wide margin. WPI also conducts an annual competition using external judges from industry, government, and academia. In the last several years, projects from the Venice Project Center have either won this competition or placed in the top three spots. Student work has also been recognized externally through presentation at international conferences and publication in archival journals.

When needed, continuous improvement methods include workshops for faculty advisors, changes in preparation course structure and content, improvements in screening student applicants for the global program, and

Implementation on Other Campuses

We recognize that significant barriers exist for transfer of WPI's system to other universities. These include faculty, institutional, and student barriers. It would be unrealistic and perhaps a mistake for other schools to try to clone this system. However, if your educational philosophy and beliefs about how students best learn are consistent with that outlined above then there are ways to "make it work". Some suggestions are offered below.

Faculty Barriers

The barriers to faculty participation include time away from research and family, lack of reward, reluctance to travel, and perceived lack of academic worth. Perhaps the answer to these issues is that supervising undergraduate study abroad is not for everybody. However, short-term structures (see below) minimize research and family impacts. Creative combinations of already established international faculty contacts, graduate students, and undergraduate projects could actually make a global experience productive for a research program. Do you have contacts somewhere else in the world that could benefit from having a student team tackle a problem for which they don't have the time or resources? Could that problem be something related to your own research?

Institutional Barriers

The institutional barriers consist of concerns about the academic worth of the experience, curriculum constraints, awarding academic credit, and the calendar. Creative repackaging of curriculum requirements and employment of accepted assessment processes can solve most of these problems. Proven evaluation methods can be used to understand and demonstrate the intellectual worth of the global experience. This leads to minimal worries about granting academic credit.

Institutions should look at what the curriculum and offer opportunities to complete degree requirements elsewhere. Consider collaborating with the departments that own the non-technical courses that may be part of a general education requirement. Is there a way to combine efforts so that students can receive some credit towards the general education requirements while preparing to work on an engineering problem in Thailand?

Explore offering a real-world program (practicum) that revolves around solving problems that allows students to actually experience working within a global environment. Is there a way to combine a preparation for an experience in Central America with credit for studying Spanish?

Explore alternatives to the long, one-year study abroad program. Offer a semester, an eight-week program, a summer program, or a between semester program. Consider a modular package that provides several related curriculum requirements (general education, humanities, and engineering electives) in an on-campus classroom environment during the first half of a semester, followed by an integrated project experience off-campus in the second half of the semester.

Student Barriers

Student barriers include lack of interest, perceived detractions to progress in their major, language issues, reluctance to travel, and cost. Progress in the major can be assured through creative institutional structures as mentioned above.

Interest can be generated and maintained at a high level using past student participants. They are the best means to let others know that it can be done. Hold annual fairs, involve past student participants in admissions presentations, in other words, create a buzz. Are students asking each other "when are you going abroad?" Location is another key to getting students involved. Offer alternatives to European cultures. Students have high interest in living and working in other areas. Study abroad destinations for all disciplines are no longer the traditional European tour. Consider places like Latin America, Asia, and Africa.

Global academic options must be kept affordable for students. If possible, financial aid should be extended to cover the added expense of sending students off-campus to fulfill an academic requirement. Is there money available in the local community to sponsor students on this kind of educational experience? Can alumni donors be cultivated to help defer travel costs?

Provide training in language and customs of the destinations - a foreign language requirement is helpful, but it needn't be a barrier. Students can be prepared for their experience with a basic understanding of how to communicate, what to expect culturally, and how not to offend members of the host culture. Institutionalizing a formal health, safety and risk management process can mitigate both student and faculty reluctance to travel. All participants need to know that their destination is acceptably safe and that structures are in place to handle the inevitable non-academic issues and emergencies that arise.

Summary

Given what we've learned over the past two years in terms of the role of America, the perception of Americans, and the misperceptions so many have of our intentions, isn't it

our obligation as educators to provide what has been so sorely missing? An international experience that will truly prepare our students for the world they're entering . . . one that has changed so drastically in the years since we stepped onto campus ourselves. The world has changed… perhaps it is time for engineering education to change with it.

The right combination of institutional flexibility, student engagement, instructional design and faculty interest will make that change happen. Student learning will progress from the passive, superficial level to self-actuated, contextualized, deep learning. They will grow intellectually and personally in ways that cannot occur on campus. These students will not just earn academic credit for their experience; they will earn credit from professionals in the world outside the university. Excellent examples come from our students' Venetian experiences that are chronicled in places like *National Geographic* (magazine and television) and the *Smithsonian* magazine (18-20).

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