

## How can universities provide a global perspective for engineers? One institution's solution

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### Abstract

Worcester Polytechnic Institute (WPI) has long embraced a project-based curriculum that now extends to the four corners of the globe. With established programs in Europe, the Far East, Latin America, Australia, the US and new initiatives in Africa, WPI provides opportunities for undergraduates to complete meaningful off-campus experiences. WPI offers students the freedom to complete degree requirements away from campus in a professional experience under the direct supervision of WPI faculty, an experience that is unrivaled by traditional international study abroad. The impact of successfully completing professional-level projects at remote locations is that students solve real-world problems while being immersed in a different culture. With over 350 students leaving campus this year and substantial growth predicted for the 2000-2001 academic year, students are recognizing the unique benefits of the Global Perspective Program at WPI. This paper will provide the rationale for the program and its place in the overall curriculum at WPI, a history of the program's formation, recruitment and training of faculty and the outcomes for students. Finally this paper will outline how the Global Perspective Program at WPI addresses some of the issues raised by ABET Engineering Criteria 2000.

### I. Introduction

There has been a call for changes in engineering education by both representatives of academia and industry. The ASEE's report, *Engineering Education for a Changing World*, presents a typical viewpoint:

[E]ngineering colleges must not only provide their graduates with intellectual development and superb technical capabilities, but, following industry's lead, [they] must educate their students to work as part of teams, communicate well, and understand the economic, social, environmental, and international context of their professional activities.<sup>1</sup>

The breadth of skills needed by graduate engineers in the 21st century is also addressed by the National Science Foundation's *Restructuring Engineering Education: A Focus on Change*<sup>2</sup>. There an integrated systems approach is highly regarded as the way to accomplish the changes needed in the curriculum today.

As the call for new pedagogical thinking and curriculum planning is heeded, reforms in the accreditation process by ABET have been initiated. ABET's Criteria 2000 <sup>3</sup> has instituted many of the same ideals as outlined by NSF and ASEE in their recent reports. To satisfy ABET's new criteria engineering and technological institutions must show evidence that graduating seniors possess certain abilities. These abilities include areas that have not been traditionally addressed by ABET in the past. The criteria now encompass such things as:

- an ability to function on multi-disciplinary teams
- an ability to understand professional and ethical responsibility
- an ability to communicate effectively
- an ability to understand the impact of engineering in a global/societal context
- a recognition of the need to engage in life-long learning
- a knowledge of contemporary issues

The practice of engineering, science and management is best learned by a student through a process of 'initiation into a tradition' as an apprentice to a master <sup>4</sup>. Such an approach to engineering education was anticipated by WPI over 25 years ago and has been enhanced by the addition of several project centers located around the world. WPI's focus on learning by experience is shared as well by many current educational theorists and practitioners, supported by leading work in the social and cognitive sciences <sup>5,6,7,8,9</sup>. Researchers in these fields increasingly recognize that, in order for students to become full members of a 'community of practice,' it is essential that they have opportunities for 'legitimate participation' <sup>5</sup> in the practices of that community. WPI Global Perspective Program exploits the converging interests of industry, cognitive science and engineering education.

## II. Rationale and history

In 1970, WPI adopted a new curriculum, called the WPI Plan. The WPI Plan replaced a traditional, course-based technical curriculum with a project-based program emphasizing teamwork, communication, and the integration of technical and societal concerns. Among the degree requirements of this program are three substantive projects: one in the humanities and arts, one in the student's major area of study, and one that explores the interrelationship between society and technology. This last project, the Interactive Qualifying Project or IQP, is an interdisciplinary project, equivalent in credit to three courses, in which small teams of students work with faculty advisors to address problems at the society/technology interface; often these problems are proposed by public and private agencies and organizations.

Another aspect of the curriculum that was impacted by the plan was the organization of the academic year. WPI moved from a traditional semester system, to a year divided into seven - week terms. There are four terms during the regular academic year and an additional fifth term runs during the summer. The regular course load for all students is three courses per term. Classes meet everyday with the intent that more is learned for every course taken in this shorter, yet more intense, academic experience.

In 1976, the first WPI residential Project Center was established in Washington, DC. The Project Center model involves groups of students working off-campus full-time on degree-required projects for a period of one term. The students are accompanied by WPI faculty

advisors, and develop solutions to problems proposed by agencies and organizations at the site. Since that time, this program has expanded to include operations in London, Venice, Bangkok, Boston, Puerto Rico, Costa Rica, Germany, Australia, Denmark, and Zimbabwe; current exploratory sites include new programs in Morocco and Argentina.

In the 1999-00 academic year, WPI will send approximately 360 students, including about 60% of its junior class, to one of WPI's off-campus residential Project Centers. These centers are located throughout the world, and serve as real-world laboratories in which students focus on the solution of projects dealing with society and technology. This is not a traditional study-abroad program. Instead, it is a set of satellite extensions of the WPI campus. Groups of students, accompanied by residential WPI faculty advisors, work and live for two months in one of these foreign settings while they address problems presented by local public and private agencies and organizations. This is what is known as the Global Perspective Program at WPI.

### III. The Interactive Qualifying Project

Most of WPI's off-campus projects take the form of an Interactive Qualifying Project (IQP), an interdisciplinary degree requirement at WPI linking science and technology with societal structures and values. Although these projects can encompass a broad range of topics, several identifiable themes occur frequently, environmental and ecological issues, urban studies and sustainable development, social implications of information technology, and the role of technology in the formation of public policy.

These undertakings are supported by on-campus student preparation in the social sciences, as well as by the development of a detailed project proposal encompassing a survey of the relevant literature, the establishment of clear goals, and the formulation of a methodology appropriate for achieving those goals. Each project, regardless of its area of focus, calls upon students to develop specific skills. As students receive broad problem statements from the project sponsors, they must develop specific achievable goals. The project topics typically involve subjects that are completely new to the students, who are called upon to independently acquire enough knowledge of the subjects to complete the projects.

Currently, each group of students completes a preparatory program on campus during the academic term prior to the off-campus experience. These site-specific programs seek to integrate preparation in project research, appropriate methodologies (drawn from the social sciences), and the development of a detailed project proposal. Students also prepare by studying local history, language and culture. The faculty advisors who accompany students also participate in this programming, which is coordinated and administered by WPI's Interdisciplinary and Global Studies Division. Students and faculty are not only prepared for the project topic, but for the cultural context in which the project will be executed as well.

In keeping with the interdisciplinary nature of the IQP, the student teams and faculty advisors are drawn from across WPI's fourteen academic departments, so as to bring a breadth of skills and perspectives to each project. The students work in teams of three or four, typically with students from different disciplinary and cultural backgrounds. Furthermore, every team must work closely with the professional liaisons at the sponsoring agency.

Each project is documented by an extensive formal report, typically in excess of one hundred pages, which is completed during the course of the project. This report details the students' literature search, outlines the methods to be used, documents the process by which any relevant information is gathered and analyzed, and presents conclusions, findings, and recommendations in addition to any other tangible outcomes of the project. Each project team is regularly called upon to give formal presentations of their project progress, with a special emphasis on effective professional presentation skills. Additionally, each project culminates in a formal presentation of the results of the project to the sponsors and other interested parties.

By definition every project involves issues at the interface between society and technology. In this way, the students become aware of how their work as scientists and technologists will affect and be affected by, social structures and values. Since these projects take place far from campus, usually in a foreign setting, the students are confronted daily with the reality of living and working in an unfamiliar environment. This experience not only broadens their view of the world and their professions, but also often leads to greater levels of self-knowledge and awareness of their place in the world.

Recently a project entitled "Sustainability of Farming Systems in Northeast Thailand" was completed at one of our global sites. The International Board of Soil Resources and Management sponsored this project early in 1999. Three students interviewed Thai rice farmers to collect economic and agricultural information relating to farming practices and farm life. A nutrient balance assessment and socioeconomic profile were configured for each farm, and recommendations were developed for the farmers. Work in this area will continue with future teams from WPI.

#### IV. Faculty recruitment and training

To date approximately 20% of the more than 200 tenured and tenure-track faculty have participated in the Global Perspective Program. The development of faculty expertise and interest in these off-campus interdisciplinary projects is central to the program's success. To insure participation of faculty with the appropriate expertise, a Faculty Development program was initiated in 1997 to facilitate this effort. Faculty may apply for small grants to develop expertise and experience in areas of interdisciplinary studies, and to gain experience in the appropriate foreign language and culture. External funding has also been secured to develop specific areas of the curriculum, such as Latin American studies programs that support the project operations in Costa Rica and Puerto Rico. Faculty can be supported for the development of on campus course work on interdisciplinary or cross-cultural topics, and for the inclusion of global issues in the technical curricula.

Every off-campus project site is directed by a WPI faculty member, who works with local professionals and organizations to identify project opportunities, secure resources, and arrange for on-site housing and logistics. Because most sites run for only one term a year, most often the directors work closely with local coordinators at the site who maintain ongoing relationships with housing providers and sponsoring agencies.

Each year, faculty members are chosen from across the campus to participate as residential project advisors at the sites. These advisors travel with the students and reside on site during the entire experience. Responsibilities of the advisors include not only the typical academic issues that arise, but also issues that arise due to living on site and off-campus.

Because there are special issues that arise from being away from campus for all participants – students and faculty alike – training has been developed specifically for advisors at off-campus locations. A conscientious approach to risk management has necessitated preparing advisors for worst-case scenarios, while also providing the less experienced off-campus advisors with an opportunity to learn from their colleagues who have been away often. Areas of concern that are addressed during these training sessions include: sexual harassment, transportation, alcohol, recognizing and responding to students at risk, health and safety issues, housing concerns, students' behavior, social and personal growth, and helping students get the most of the cultural experience. All of these areas are deemed to be out of the purview of regular project advising and therefore get special attention. Professionals who offer services addressing these issues on campus are brought into the training sessions to offer expert advice about how to deal with them off-campus. Of course, every faculty advisor has contact information for anyone they might to consult with while away.

The role of advisor is critical to the success of the educational enrichment that WPI's students experience in their project work. Advisors are responsible to give continuous guidance and mentoring to all of the student teams, sometimes in areas outside of their fields of expertise. The faculty advisor becomes visible to students on site as "reflective practitioners" who are continually engaged in a process of learning and discovery through a critique of both their own and their students' activity<sup>8</sup>. In this way, students are provided with models for the lifelong learning necessary to thrive in our rapidly changing world.

## V. Outcomes for the Students

As indicated earlier in this paper, each project, regardless of its area of focus, calls upon students to develop specific skills. As students work with broad problem statements and develop specific goals for their project, they are actively engaged in open-ended problem solving. Typically project topics are outside the scope of the students' areas of study, and therefore the students must learn how to learn about new subjects. Teamwork skills are honed and practiced throughout the experience as students work together to produce a solution. The formal documentation and presentation skills required to successfully complete an IQP off-campus insures that students master how to communicate in a variety of mediums and for a variety of audiences. Because the projects involve issues at the interface between society and technology every student becomes aware of the impact that engineering decisions can affect, and are affected by society and values. A heightened sense of self-knowledge and awareness of their place in the world is an attribute that every student returns with to campus, along with an increased awareness of international issues never contemplated before.

Re-entry programs for returning students from off-campus project centers have also been initiated. Pilot results show the need for addressing some of the holistic issues that students face as they return to campus life. A process of self-reflection and awareness is initiated and

facilitated by members of the professional staff in the Global Perspective Program and the Counseling Center on campus. By being asked open-ended questions about their experiences, students begin to come to terms with how they have been changed by their experience off campus. They are also given guidance as to how the experience can be used to inform their future academic and professional endeavors.

## VI. Continuous Improvement and ABET Criteria

To maintain a continuous cycle of improvement, various assessment measures are in place and more are in development. Every year there is a detailed evaluation of all IQPs completed at WPI. Each review to date has shown evidence that the projects done off campus are rated higher than the on campus projects. In fact, for IQPs completed during the 98/99 academic year the difference now exceeds one full point on the five point rating scale for overall quality and is highly statistically significant.

Demographic studies of the makeup of students who go off campus, however, indicate that the academic records of the students completing off campus projects are not significantly different from those of the student body as a whole. This suggests that the enhanced quality of the off campus projects is due to the nature of the project experience.

This year for the first time the review process was structured around ABET's outcomes criteria. WPI has always maintained that the IQP experience contributes to student attainment of several of the ABET outcomes including the ability to communicate effectively, the understanding of professional and ethical responsibilities, recognition of the need and ability to engage in lifelong learning, knowledge of contemporary issues, understanding the impact of engineering solutions in a global and societal context, and the ability to work in interdisciplinary teams. Results from this year's review indicate that the IQP contributes significantly to all of these criteria. High quality project work leads to substantial progress toward meeting the important ABET educational goals<sup>10</sup>.

Also important to this critical learning experience is the impact that logistics can play. Providing students with enough appropriate facilities and support while at an off-campus project center is necessary to insure success. While students are still on site, they are asked to evaluate logistics concerning accommodations and support provided. The results from these surveys are reviewed by the administration in the Global Perspective Program. Logistical changes are made where warranted. Because of the feedback provided by students in the past, WPI now provides every project team with a laptop computer for use while off-campus. In this way, WPI's Global Perspective Program plans to maintain the integrity of the Program through continuous self-evaluation and improvement.

## VII. Summary

The Global Perspective Program at WPI provides a model for technological education that incorporates a meaningful global experience for students. This model encourages progress toward addressing the student skills and attributes called for by professional associations, funding agencies and accreditation agencies. At WPI programs of assessment, student

preparation and re-entry, and faculty and curriculum development further support these efforts. Rapid growth of the program provides evidence that WPI students understand the value of this type of international experience.

#### Bibliography

1. "Engineering Education for a Changing World," A Joint Project by the Engineering Deans Council and the Corporate Round table of the American Society for Engineering Education, 1994.
2. "Restructuring Engineering Education: A Focus on Change," Division of Undergraduate Education, Directorate for Education and Human Resources, National Science Foundation, April 1995.
3. "Criteria for Accrediting Programs in Engineering in the US: Effective for evaluation during the 1995-96 accreditation cycle." Accreditation Board for Engineering and Technology, 1995.
4. Dewey, J., *John Dewey on Education: Selected Writings*. (R.D. Archambault, ed.). Chicago: University of Chicago Press, 1974.
5. Lave, J., and Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.
6. Hutchins, E., *Cognition in the Wild*, Cambridge, MA: MIT Press, 1995.
7. Dreyfus, H.L., and Dreyfus, S.E., *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*, New York: Free Press, 1986.
8. Rogoff, B. (1990) *Apprenticeship In Thinking: Cognitive Development In Social Context*, New York: Oxford University Press.
9. Schön. D.A., *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass, 1987.
10. Woods, D.W., "Review of IQPs Completed in 1998/99 – Report to the Faculty", Worcester Polytechnic Institute, 1999.

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