

HOW ONE INSTITUTION PROVIDES A GLOBAL PERSPECTIVE FOR ENGINEERS

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Abstract Worcester Polytechnic Institute (WPI) has incorporated a project-based curriculum that now extends around the globe. With dynamic programs in Europe, the Far East, Latin America, Australia, and the US, WPI provides opportunities for undergraduates to complete meaningful off-campus experiences. WPI offers students the freedom to complete three different degree requirements away from campus under the direct supervision of WPI faculty. This experience is unrivaled by traditional international exchange. This paper will outline how the WPI addresses the issues raised by ABET Engineering Criteria 2000. It will focus on aspects of the program that are clearly connected to multi-disciplinary teaming, professional and ethical responsibility, communication competence, a real understanding of the impact of solutions in a global and societal context, knowledge of contemporary issues and the motivation for life-long learning. This paper will emphasize current initiatives with regard to outcomes assessment, risk management, and implications for the future.

Index Terms ABET Criteria 2000, global perspectives for engineering students, international experiences for engineering students

INTRODUCTION

There has been an increase in the call for internationalizing higher education by representatives of government, academia and industry. President Clinton's recent memorandum to the heads of executive departments and agencies regarding the International Education Policy states:

To continue to compete successfully in the global economy and to maintain our role as world leader, the United States needs to ensure that its citizens develop a broad understanding of the world, proficiency in other languages, and knowledge of other cultures... It is the policy of the Federal Government to support international education. We are committed to:

- Promoting study abroad by U.S. students...
- Expanding high-quality foreign language learning and in-depth knowledge of other cultures by Americans...[1]

The ASEE's report, *Engineering Education for a Changing World*, presents another 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. [2]

The National Science Foundation addresses the breadth of skills needed by graduate engineers in the 21st century in its *Restructuring Engineering Education: A Focus on Change* [3]. 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 [4] 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

Students best learn the practice of engineering, science and management through a process of 'initiation into a tradition' as an apprentice to a master [5]. 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 [6-10]. Researchers in these fields increasingly recognize that, in

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order for students to become full members of a 'community of practice,' it is essential that they have opportunities for 'legitimate participation' [6] in the practices of that community. WPI exploits the converging interests of industry, cognitive science and engineering education.

WPI'S UNIQUE OPPORTUNITIES FOR GLOBAL EXPERIENCE

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. WPI's off-campus opportunities take the form of one of these three projects.[11,12]

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. 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, California, Madrid, San Juan (Puerto Rico), San José (Costa Rica), Zurich, Melbourne, Limerick and Copenhagen; current exploratory sites include new programs in Taipei and Hong Kong. These centers serve as real-world laboratories in which students focus on projects. This is not a traditional study-abroad program, but rather an opportunity to complete a degree requirement at a remote location with all of the support systems in place to guarantee success.

DEGREE REQUIREMENTS FULFILLED OFF-CAMPUS

WPI requires every student to complete three required projects before graduating. One of these projects is completed in the area of the Humanities. The intent is to provide students with enough background to learn how the mind creates, appreciates, and criticizes something in the humanities or arts. This is truly an unusual requirement for engineers and technologists! The senior project is similar to what other institutions might call a capstone project – a culminating project done in the specific discipline that involves analysis, synthesis, and design. Students have the opportunity to complete either of these required projects at an off-campus site.

However, most of WPI's off-campus projects take the form of an interdisciplinary project requirement that links 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.

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.

MANAGING THE PROGRAM

Just as the geographic scope of the Global Perspective Program has grown steadily since its beginnings nearly three decades ago, student participation in the program has been climbing at a rapid rate. Participation hit the 100 students per year mark in the mid-1980s, and reached 200 students per year about a decade later.

Today, more than 500 students (out of an undergraduate population of 2,700) complete an off-campus project each year, and about 60 percent of all students will have had an off-campus experience--the majority at international sites--before they graduate. In all, more than 3,600 students have participated in the program since 1974.

A program of this size has demanded careful attention to the recruitment and placement of student participants. Each year students are recruited for participation in the program a full academic year in advance of when they will depart. Students begin a lengthy application process in September that is comprised of a written application, an autobiographical essay, a review of their transcript and an individual interview with the faculty member responsible for the project site (Center Director). The Center Director makes all selection decisions for the sites that they oversee with a careful eye to balancing talents and preferences of students. Students learn of their placement early in January.

Another aspect of the curriculum that allows for the flexibility necessary to offer these opportunities is the organization of the academic year. Over twenty-five years ago 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. While a student is at a project center completing a degree-required project, they are completing the equivalent of three courses.

All of these off-campus undertakings are supported by on-campus student preparation, as well as by the development of detailed project proposals during the academic term prior to the off-campus experience. All student participants are enrolled in the preparation activity required before departing for the site. This activity is equivalent to one and a half courses and is completed in the term immediately preceding departure. In the first week of

this preparation, the Center Directors in collaboration with the resident faculty advisors determine who the teams of students will be. Again, this is done while carefully considering each student's talents, prior experience and project preference.

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. 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 (IGSD). Students and faculty are not only prepared for the project topic, but also for the cultural context in which the project will occur.

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 of typically three to four students 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 to the sponsors and other interested parties.

One example of a WPI project

The breadth and nature of the projects is perhaps best illustrated by a specific example. In January and February of the year 2000 a student team, sponsored by the International Board of Soil Resources and Management (IBSRAM) and the Ubon Rice Research Center (URRC), completed a project entitled Sustainability of Farming Systems in Northeast Thailand. A WPI faculty resident advisor whose area of disciplinary expertise falls within Computer Science provided academic guidance and oversight of the project. The team, comprised of an electrical engineer, a mechanical engineer and a biotechnologist, represented *interdisciplinary* in every sense of the word. These students went into the field and interviewed Thai rice farmers to collect economic and agricultural information relating to farming practices and farm life. The team configured a nutrient balance assessment and socioeconomic profile for each farm. Recommendations were developed for the farmers and the results of this project were presented to IBSRAM, the URRC and the Thai Department of Agricultural Extensions.

THE OFF-CAMPUS PROJECT EXPERIENCE AND ABET CRITERIA

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 interdisciplinary project off-campus insure that students master how to communicate in a variety of mediums and for a variety of audiences.

Because the interdisciplinary projects involve issues at the interface between society and technology every student becomes aware of the impact of engineering decisions on 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.

WPI's goal is to maximize the benefits of this experience not only for the students, but also for all involved. Developing a comprehensive assessment plan for the entire program, given its complex nature, is indeed a challenge. The Interdisciplinary and Global Studies Division contracts an Assessment Coordinator to oversee the assessment and continuous improvement efforts of the Division. This Coordinator has utilized a variety of surveys, interviews and other tools to evaluate many aspects of the operation. The main product-oriented evidence currently used to assess student outcomes is the written report. Every year there is a detailed evaluation of all interdisciplinary project reports completed. Each review to date has shown evidence that the projects done off campus are rated higher than the on campus projects – when looking at the final product, not the process.

For the first time in the summer of 1999 the review process was structured around ABET's outcomes criteria. WPI has always maintained that the interdisciplinary 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 that year's review indicate that these projects contribute to all of these criteria. High quality project work leads to substantial progress toward meeting the important ABET educational goals [13].

New initiatives are underway in a variety of areas aimed at evaluating the process. This issue is problematic since the

process is directly dependent upon advising methodologies that vary among faculty advisors. The continuous improvement feedback loop is under development. The report issued by the coordinator of the summer review usually provides specific guidelines for improving overall project quality. We are actively pursuing effective solutions for these problems [14].

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 [10]. In this way, students are provided with models for the lifelong learning necessary to thrive in our rapidly changing world.

ABET's educational goals and the proven benefits to WPI students and faculty has been leveraged to support the program. In 1995-96 about 150 students traveled to an off-campus site to complete a degree requirement at one of 12 project centers. In the year 2001-02 over 500 students will travel to one of 24 project centers to take advantage of the opportunity provided by WPI. This is important to note in a time when many programs that provide study abroad at different universities are struggling for their survival. WPI has recognized that in order to provide a meaningful experience to students that truly addresses the criteria put forward by ABET and other agencies, then the opportunities for students to participate had to be expanded and made available to all students. By leveraging the demands made by an outside accreditation agency, the program at WPI is robust and thriving. The program provides a unique opportunity for engineering and technology students to gain real insight into the global and societal context of the impact of decisions of the professions.

MANAGING RISK

In order to understand WPI's program and how risk is managed, it is important to understand the context. WPI has several levels of participation in the project centers that contribute to this model's success. Each project center has a full time faculty member associated with it referred to as a center director. This center director oversees the pedagogical concerns associated with projects, selects the student participants for their site and works with the local coordinator. The local coordinator is a resident of the site who maintains contact with project sponsors, helps to arrange housing and serves as a resident expert for the students and faculty for the site. There are full-time WPI faculty members who go with the students for the duration of the project experience who are referred to as the resident advisors. These resident advisors prepare with the students for the term before they depart for the site, live on site with

the students and advise the projects

In addition to the roles described above, the Interdisciplinary and Global Studies Division through which these residential off-campus experiences are managed also employs administrators. The leadership team for this Division is comprised of four individuals who separately oversee different components of the off-campus experience and who together decide policy and procedures that affect all participants – students, Resident Faculty Advisors, Center Directors and Local Coordinators. There are also several support staff members who facilitate all of the details involved in administering such a large program.

As the numbers of students going off campus increases, it is obvious that the division sponsoring this academic activity cannot work in a vacuum to address risk management. It only took one perceived crisis in the making to bring the right players together to form the risk management team that worries about the risk associated with sending students away to complete projects. This team is made of the Director of Global Operations in the Interdisciplinary and Global Studies Division, the Associate Treasurer for the university and an insurance and liability consultant hired by the university.

Part of the process of working towards managing the risks WPI saw itself being exposed to was defining what "risk management" means to the institution. The risk management team identifies various exposures, and measures these exposures against WPI's willingness and ability to withstand potential losses resulting from these exposures. The team determines how to implement policies to best control these identified risks with appropriate procedures. These policies and procedures are reviewed each year and are specific to each site.

In addition to the academic preparation that students participate in, they are also given orientation and preparation for the cultural, religious and ethnic differences they may encounter off-campus. This may include specific language training, depending on the site. Faculty members with expertise in the area provide a general history of the site where the students are going. Students are instructed as to proper dress, proper etiquette, and how to expect the host country nationals to treat them.

Students are also provided with an orientation session run by the professional staff of the IGSD. The professional staff covers in detail issues of health, safety, medical insurance, alcohol and drug use, WPI policies and how they are enforced while off campus, and also policies that are specific to the program that the students are preparing to participate in.

While participants are off-campus they still have access through email, telephone, and fax to all support resources on the WPI campus as described previously. The WPI risk management team is confident that by providing written material to the students and their families along with a review of all the material, policies, and issues that all participants are as prepared as possible before they leave

campus.

Each year, faculty members apply from across the campus to participate as residential project advisors at the sites. The resident advisors are chosen by the leadership team of the Interdisciplinary and Global Studies Division. 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 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, drugs and 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 help design and facilitate the training sessions to offer expert advice about how to deal with the issues off-campus.

WPI believes that effective risk management is a combination of two methodologies. The first is a philosophical approach that aims to identify, analyze, and manage risks. The second must be a practical approach that is tailored to each site. The ultimate goal of this combination is to protect the students, the advisors, the program and the institution.

SUMMARY

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 and faculty preparation, curriculum development, and careful attention paid to the issues of risk management further support these efforts. Rapid growth of the program provides evidence that WPI students understand the value of this type of international experience.

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