Development and Implementation of Senior Design Projects at International Sites

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Abstract

ABET 2000 criteria state that undergraduate engineering students should have "the broad education necessary to understand the impact of engineering solutions in a global and societal context".[1] For the past 25 years, WPI has addressed this need by establishing a network of international centers where students complete projects focusing on socio-technological issues. More recently we have expanded the global project program to include projects in the students' major disciplines. Several senior capstone design projects have been completed at international sponsors' agencies. The teams are composed of competitively selected WPI engineering students who work on-site to solve a key problem posed by the sponsoring agency. During the process the students experience hands-on application of engineering projects and learn to work as technologists within the engineering domain of the host country. The outcome of their work is a fully documented professional report containing complete results and key recommendations, as appropriate, as well as a high quality presentation of the highlights of their findings to the sponsors. This paper describes our experiences in developing and building the project program to include senior capstone projects. Our experiences with identifying sponsoring agencies or companies, preparing students for international project work, and remote advising of student projects will be discussed. We will also describe some of the benefits for the students, the university and the sponsors that have been derived from these projects.

Background

In 1970, Worcester Polytechnic Institute implemented the WPI Plan, an innovative, project-based undergraduate program unlike any other engineering program in the world. The objectives of the Plan were to provide a flexible, challenging program to help students "learn how to learn"[2], as opposed to the rigidly prescribed curricula at engineering schools of the time. Under the WPI Plan, all students are required to complete three projects as degree requirements: a Humanities Sufficiency, an Interactive Qualifying Project (IQP), and a Major Qualifying Project (MQP). After thirty years, these project-based activities remain the core of the undergraduate curriculum at WPI. The Major Qualifying Project allows students work in teams on real-life projects in the students' major areas of study. The students solve problems typical of those that will be encountered as entry-level professionals. These projects allow students to demonstrate most if not

all of the Criterion 3 Program Outcomes dictated by ABET 2000.[1] Students work on these projects throughout their senior year, devoting at least one-fourth of their academic effort or a three-course equivalent to the project. Recently, other engineering colleges have also begun to incorporate project-based activities in their curricula as a means to achieve these broad-based educational goals.

Unlike other programs, the WPI Plan includes two additional projects, the Humanities Sufficiency and the Interactive Qualifying Project (IQP). These projects are unique in engineering education. The Humanities Sufficiency requires students to complete an integrated series of humanities courses and conduct a thematically related research project (a one-course equivalent). In the IQP, students are challenged to understand and solve a problem that involves interactions between science, technology and cultural or societal issues. Students may learn how social issues affect the development of technology, or how technology impacts society. Interactive Qualifying Projects, typically completed by junior-level students, like the MQP, require the equivalent of one-fourth year of academic activity, which may be spread out over the entire year or concentrated in one seven-week term (half of one semester).

In support of these project goals, WPI has developed a network of domestic and global project centers. These centers have traditionally been sites for IQP project activities, focusing on problems associated with the social-technological interface such as environmental concerns, legislation and regulatory issues, use of technology by non-technological agencies, etc. At these project centers, students work for a term of seven weeks on site with sponsoring organizations, companies and government agencies under the guidance of WPI faculty. WPI's first domestic IQP project center opened in Washington DC in 1976, followed by the first global site in London in 1978. Based on the success of the IQP project centers, several domestic MQP sites have been opened more recently. Currently, there are four (4) domestic MQP centers, three domestic IQP centers, eight (8) global IQP project centers, and two (2) global Humanities Sufficiency sites. Further information about the WPI Projects Program can be found at the WPI Projects website[3].

Global Capstone Design Projects

Increasingly, engineers are required to work on projects that involve international collaborative engineering efforts. In order to allow students to gain experience working on engineering problems in a global setting, the WPI projects program has been expanded to include a limited number of opportunities for students to work on projects at international sites. Unlike the typical year-long on-campus design project, completion of a significant capstone design experience in a short, seven-week period requires careful planning and selection of projects. The components that comprise a successful project include suitable project topics, good projects sponsors, sufficient student preparation, attentive faculty advising as well as strong administrative and logistic support.

Projects and Sponsors

Selection of projects is a critical component in the success of the student design experience.

Suitable projects challenge the students with real-life problems, but must not be so large or complex that the project cannot be completed in the allotted time. Furthermore, the projects should encompass most of the major stages of the design process, including problem formulation and definition, development of concepts, concept selection and refinement, analysis, prototyping and testing. Not all projects will cover all aspects of the design, but a challenging project will provide the students with the opportunity to apply their knowledge and skills in the context of a real design problem. Projects should require the students to use their creativity and decision making skills to complete the design tasks. Industrial sponsors can provide a wide range of project opportunities that meet these educational objectives. However, it is important that company sponsors understand that the project is primarily an educational experience, not all students possess superior engineering skills and abilities, and the outcomes are measured according to the educational objectives, which are not always the same as the corporate goals. Carefully selected projects, however, are able to satisfy both educational and corporate objectives.

Local companies sponsor over half of all WPI senior engineering projects. In spite of the availability of a specified technical liaison at the company, on-campus project students receive the majority of their technical support from faculty advisors. Student teams work on campus and meet weekly with their faculty advisors and most often use WPI laboratories and shops unless the project requires use of special facilities at the sponsoring company. Company liaisons are available to answer questions and guide the project, but do not typically work closely with the students on a day-to-day basis. Students present quarterly progress reports to their sponsoring companies.

When students conduct projects at the sponsor's site, technical advice is provided by the company liaison. Thus, the liaison must not only have the requisite technical knowledge to guide the project, but must also have an understanding of the educational objectives of the project program. Students must be allowed to work on the project as professionals, but with adequate guidance from the technical liaison. During a short, seven-week project, the students must have access to the liaison on a daily basis to answer questions and keep the project moving. Laboratories and equipment, computational facilities, supplies and support staff must also be made available to support the project where necessary. In addition, with global projects, the liaison often serves as a local host to the student, providing an insight to the local cultures, customs and professional practices. Thus, it is important to identify sponsors who will devote a significant amount of time for technical, administrative and cultural aspects of the students' experience.

Contacts with project sponsors can be made through various mechanisms. With the global IQP project centers, WPI has developed many contacts for these socio-technological projects. The co-authors of this paper have served as the on-site IQP project center faculty advisors at our project centers in London and Melbourne, and developed professional relationships with liaisons at those organizations. Once the professional relationship is established, the faculty advisor and sponsor liaison can discuss the technical aspects of the proposed MQP projects. This is more easily accomplished if the faculty member and sponsor can meet in person. Thus, the initial contact may be made by non-technical representatives of the sponsoring agency and other WPI personnel, who then facilitate the development of the technical relationship. By combining both IQP and MQP

projects at the same site, we can offer a wide variety of project experiences to our students while also providing the project sponsors with students of different skills for various projects. WPI establishes a track record for good project work in the IQP projects that is carried over to the MQP projects.

Project sponsors may also be derived from existing professional relationships between faculty and potential sponsors. These relationships may have developed from professional conferences, consulting or research work between the faculty and sponsor. Project sponsors that have been involved with MQP projects often develop closer ties with the WPI faculty. This increased professional association has led to research collaboration and the possibility of student exchange at the graduate level.

Student Selection and Preparation

Students for global projects are selected on a competitive basis. The faculty advisor advertises projects and students complete a written application and interview. Because these students must work without close faculty supervision, it is imperative that they possess strong academic and technical skills. In addition, they must have demonstrated teamwork ability and interpersonal skills, communications skills and strong motivation and interest in the project topic. Students are selected at least one semester before the off-campus project is started, and during that time they may be required by the project advisor to complete any courses needed as technical background for the project. During the seven-week term immediately preceding the project, students register for a one-half course equivalent and complete a project proposal. During this period, the students become familiar with the project and sponsoring company, conduct background research and may develop preliminary design concepts and/or analysis of existing products. This activity familiarizes the students with the project and allows them to be productive on the project as soon as they arrive at the global project site. The project may also be concluded with a period of project activity upon return to the campus where the students complete the necessary documentation for the project. Thus, the project activity is spread out over a significant portion of the academic year in a manner similar to the on-campus projects, however, the intense project experience occurs during one seven-week period.

Faculty Advising

Faculty advising for global capstone design projects may be conducted with a variety of mechanisms. It is not always feasible to send a faculty member to the global project site to advise students and consult with the liaisons. We have found that a good internet connection is necessary to facilitate communication between students at remote sites and faculty on campus. Students communicate with their faculty advisors via email at least weekly and often more frequently. Project meetings can also be conducted over the Internet using utilities such as NetMeeting for video-conferencing. Due to the expense, international telephone calls are limited to emergencies, but we have not found this to be necessary. If the MQP projects are conducted simultaneously with IQP projects at the global project center, the IQP faculty advisors or other local WPI staff can

handle local support for administrative problems, and the MQP project advisor and sponsor liaison are responsible for technical support. On some projects, the faculty advisor has visited the project site during the middle of the term (week 4) to meet with the students and liaison and monitor student progress. Due to the expense of international travel and other obligations of the faculty member, this is not always possible.

Outcomes

The results of these projects have been extremely successful. As with any on-campus project, students complete their capstone design experience, including full documentation in the form of a technical report and formal oral presentation to their sponsors. In addition, the global projects allow students to become familiar with engineering practices in a different country, including such issues as differences in standards and regulatory practices. Student teams work independently, communicate over large distances with faculty and sponsors at remote sites in different time zones, using modern communications tools. All of these skills enhance their professional experience. In addition, they have the opportunity to travel abroad and work with people from different cultures. Benefits to the sponsors include the project results, including input from the faculty advisor. Many sponsors comment on the fresh perspective provided by the American students, and enjoy the interaction with these enthusiastic and bright young engineers. Benefits to the university include international exposure and the ability to provide a wide range of project experiences to our students. Although these projects are not suitable for every student, our experience has shown that the effort involved in development of off-campus projects at global project centers is well worth the effort.

Bibliography

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