Teaching the Necessary "Soft Skills" through Corporate-based Projects

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More than twenty-five years ago, the senior faculty at WPI revised the conventional classroom-based curriculum by making performance in projects—rather than accumulation of credit hours in classrooms—the fundamental degree requirements for the WPI B.S. degree in science, engineering and management. The objectives in undertaking what proved to be one of the most massive and enduring experiments in recent years in undergraduate engineering education reform touch upon at least two of the themes of this conference:

- How are universities creating new relationships with industries?
- How are the necessary "Soft Skills" being integrated throughout today's curricula?

In our view, the necessary "Soft Skills" recently have been articulated best by the new "ABET Criteria 2000," Criterion 3, which states that Engineering programs must demonstrate that their graduates have:

a. an ability to function on multi-disciplinary teams;
b. an understanding of professional and ethical responsibility;
c. an ability to communicate effectively;
d. the broad education necessary to understand the impact of engineering solutions in a global/societal context;
e. a recognition of the need for and an ability to engage in life-long learning;
f. a knowledge of contemporary issues.

These "soft skills," while framed in contemporary language, answer remarkably closely to the first stage of the traditional Medieval Liberal Arts curriculum, the "trivium," which covered the essential tools needed for serious inquiry—grammar, rhetoric and logic.

In contrast, the new ABET Criteria also articulate expectations for disciplinary "content" achievement (which the historian can correlate with the "Quadrivium" of the Medieval curriculum), as follows in ABET's language.

Engineering programs must demonstrate that their graduates have:
a. an ability to apply knowledge of mathematics, science and engineering;
b. an ability to design and conduct experiments, as well as to analyze and interpret data;
c. an ability to design a system, component, or process to meet desired needs;
d. an ability to identify, formulate, and solve engineering problems; and
e. an ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

While the WPI project program aims to promote student outcomes addressing both sets of achievements, we will focus in this paper on the "soft skills" of analysis and communications that have for centuries been recognized as the foundation for all successful intellectual inquiry, and are being recast by ABET and others in contemporary terms for modern engineering education.

The undergraduate educational goals as voted by the WPI faculty are:
- to lead students to develop an excellent grasp of fundamental concepts in their principal areas of study;
- to gain a mature understanding of themselves; and,
- most importantly, to form a deep appreciation of the interrelationships among basic knowledge, technological advance, and human need.

The principal mechanism selected by the faculty to effect these goals are student projects, of which each WPI student must complete three to graduate:
- The Humanities project, which measures whether the student has achieved a sufficient background in a self-selected area of the humanities or arts to be likely to continue lifelong learning in that area.
- The "Interactive Qualifying Project" (or IQP) which assesses the capacity of students to reflect on the impacts of science and/or technology on societal values and structures.
- The "Major Qualifying Project" (or MQP) which measures the ability of students to begin working on open-ended professional problems at a level assumed of someone beginning professional practice or graduate school.

While all three have the potential to promote the "necessary soft skills" through industrial sponsorship, most projects involving corporate issues are Major

Qualifying Projects and, to some extent the IQP, so for the remainder of this paper, we will concentrate on these two nine-credit-hour projects that are degree requirements at WPI.

Let's take each of the ABET criteria regarding the "soft skills" separately.

a. An ability to function on multi-disciplinary teams.

At WPI, the IQP generally challenges students to demonstrate an outcome requiring multi-disciplinary team activity. Usually students work together on topics that are interdisciplinary in nature, typically in teams which involve students and advisors from different disciplines. In addition, for those roughly one-third to one-half of IQP's that are externally sponsored, the disciplinary mix is further enhanced by the involvement of professional liaisons whose backgrounds are often different from those of the WPI students.

In addition, the majority of MQP's in engineering are now sponsored by corporations, because from the corporate point of view, such investments pay off well in terms of nurturing future technical professional hires. Students working on such projects typically interact with professionals from a wide variety of backgrounds.

b. An understanding of professional and ethical responsibility.

The WPI faculty strongly believes that any project-based program, in and of itself, confers an understanding of professional and ethical responsibility because of the following expectations existing within corporate cultures:

- the need to work with others on teams, and to assess differing individual needs and share responsibilities;
- the need to respond professionally to externally-sponsored topics, that implicate all the complexities of the world outside academe;
- the necessity for designing and sticking to a timetable, so that a project which other people outside the academy are depending upon is done "on time and within budget";
- the necessity of learning what the professional expectations are in terms of doing a thorough literature review and quoting all one's sources in a fashion that is professionally and ethically responsible within one's discipline;
- in addition, many (though clearly not all) IQP's involve issues that deal directly with ethical concerns within the profession, such as environmental pollution or decision-making of engineers in crucial situations.

c. An ability to communicate effectively.

In framing the WPI Plan, the faculty recognized that engineering students acquire communication skills best when they are challenged to learn and use such skills as part of their on-going engineering education. Another way of making this point is to state that at WPI we do not believe that communication skills for technically-oriented students are effectively taught only by communications, humanities, or English faculty. Such students will really learn the necessity of acquiring these skills best if the engineering, science, and management faculty lead the way in showing how important communication skills are for students in these disciplines.

Thus, every project at WPI must be fully and professionally documented in written form, and increasingly in electronic means as well. Faculty normally meet with students on a weekly basis, and review drafts of the report section by section as students complete their projects (which typically at WPI occurs over at least three of the four seven-week terms that constitute the academic year.) Students typically submit a final draft of their report two or three weeks before the report is intended to be completed for a final overview. The intent is to emulate the mode of producing professional work within the corporate environment.

In addition, for externally-sponsored projects, which in many departments exceed half of the MQP's that are completed, students have the opportunity to interact frequently with the corporate sponsors. In this way, they learn as they can in no other mode how important written and oral communications are within the corporate environment. Students recognize, for example, that the kinds of oral presentations faculty require of them to present their ideas, are very widely used within the corporate world. They quickly come to see these exercises as not "academic" but as part of the way in which professionals communicate with each other within the corporate environment.

Corporate-sponsored projects, in addition, generally require several presentations within the environment of the corporate sponsors. Students are usually asked, at regular intervals, to report to their corporate sponsors as well as their academic advisors, concerning their progress. "Proof of concept" and technical review sessions are commonplace.

Finally, all WPI students are expected to present the results of their MQP's about two weeks before their completion, on a special Project Presentation Day in the third week of April. This event is structured like a professional academic conference, with multiple oral sessions, a printed program, and an invitation list that includes not only the faculty, but juniors who will be carrying out their MQP's in the following years and representatives of the corporations who are sponsoring the actual projects. These sessions prove to be very valuable in terms of students sharpening their presentation skills and often getting valuable feedback that they can incorporate into the final version of their reports.

d. The broad education necessary to understand the impact of engineering solutions in a global/societal context.

Again, the mix of IQP and MQP requirements at WPI ensure that students all are challenged to meet these expected outcomes. The interactive projects, by definition, challenge students to define, research, and report out on a significant topic examining the interaction of science and technology with societal values and structures. Specific IQP topics range over a very large space, but all, in the end, require students to give some serious thought to how one manages in a societally responsible fashion, technologies that graduates will be creating. Students themselves frequently comment that the open-ended nature of both the MQP and IQP provide them with opportunities to consider the non-technical as well as technical issues that are so important in the education of modern engineers.

In terms of assisting students to think about their education and careers within a global context, the IQP especially has proved to be a strength. For the last ten years, WPI had promoted the IQP as an opportunity for engineering students to spend at least eight weeks abroad, carrying out an interactive project in a societal context new to them. In many cases, students must acquire new linguistic as well as cultural capacities to be able to carry out such projects. Roughly one third of all WPI students conduct their IQP's abroad so that WPI as recent surveys have indicated, has well more than twice as many students participating in international programs as its nearest competitor in this field.

e. A recognition of the need for and an ability to engage in life-long learning.

Surely this is one of the most difficult of the ABET criteria to assess. Strictly speaking, acquiring the capacity to engage in life-long learning cannot be measured in terms of the experience of graduating 21 year old students. However, the faculty at WPI believe strongly that a project-based educational program is more likely to emulate those conditions and situations which stimulate life-long learning, than the comparatively passive classroom experience of a conventional program. Working on projects requires students, by definition, to master skills of self-reliance: time management, team dynamics, meeting self-imposed deadlines, and interacting with a wide variety of sources of information and potential customers. They must identify the often-conflicting interests of different faculty and different corporate liaisons, as they try to define their topic, and then pursue the information needed to complete their project.

f. A knowledge of contemporary issues.

Again, virtually by definition, projects sponsored within a corporate environment require students to confront issues of current concern to the corporate sponsors. WPI has found the corporate world very responsive to sponsorship of projects, because corporations recognize that students often can come up with solutions that are highly cost effective (given

the expectations of support for the projects). Thus, while few corporations would assign to a student group a project vital to the bottom line in the next quarter, the concept of asking students to work on "back-burner" projects, that may develop into concepts or products of value to the company several quarters down the road, is readily accepted. Companies have proved to be, especially in the MQP, very willing to share with students and faculty access to state-of-the-art proprietarial information, the dissemination of which WPI has regulated through a legal agreement limiting disclosure. Corporate sponsorship also gives students access to the latest state-of-the-art technologies as well as concerns appropriate to the discipline of the students, who in MQP's generally work in companies in their major.

In conclusion, the kinds of contacts which the WPI project program creates among undergraduate students, faculty members, and corporate sponsors has created an entirely new set of relationships between the academic and corporate worlds. In addition to the opportunities widely available in other institutions for faculty and students at the undergraduate level to interact with the corporate world (through such functions as cooperative education or summer programs) the IQP and MQP program, in addition, commits students and faculty to a major and serious time commitment in tackling a corporately-sponsored project. WPI calculates that a team of three students put in approximately a thousand person hours in assessing, solving, and documenting the solution to a corporate problem that has been accepted as an MQP topic.

In order to foster and support closer contacts with corporations, WPI has designed a program called Corporate Project Centers. Corporate Project Centers are created through an agreement with WPI and the sponsor to engage at least three project teams per year, and to provide a $10,000 project fee to WPI for managing the projects, in addition to all direct costs. Corporate sponsors of these programs have found them a very valuable way not only of engaging students, under faculty guidance, to solve problems at the appropriate level, but also of forging alliances with WPI. The faculty member who directs the Corporate Project Center becomes in effect the principal contact person that the corporation has with the institution with respect to exploring areas of common interest in research, graduate studies, or professional consulting. Corporations, especially in the current environment of downsizing, with very reduced staffs in human resources or college relations, also find the project connection is very valuable in maintaining, at a very low cost, contacts with a college very likely to provide them with entry-level professional hires. MQP's and IQP's provide a far better insight into the capacity of graduating students to make significant contributions to the corporation than is the case with transcripts, GPA's, or even the much less self-directed activity typical of summer jobs or co-op placements.

The proof, as always, is in the pudding. Recruiters often comment that WPI graduates are closer to hires who have been out at work for a year or two, than to recruits coming straight from the classroom. The faculty at WPI believe the difference is in the project program, which not only requires of every student the demonstration of entry-level technical competence through the MQP, but also through the project program overall the capacity to think in larger contexts about professional practice and to articulate those views effectively to a broad audience.

Biography

Lance Schachterle joined WPI as an assistant professor of English in 1970, and served from 1984 to 1993 as chair of Interdisciplinary Studies, overseeing WPI's unique Interactive Qualifying Project program with its extensive experimentation in global education. Schachterle was appointed Assistant Provost for Academic Initiatives in 1993, and currently is in charge of first-year and pre-college academic program development including management of the first public high school for gifted mathematics and science students in the state (the Massachusetts Academy.) Both at the Academy and at WPI, he has been involved with structuring programs to serve student populations currently under-represented in mathematics and science.

William W. Durgin joined WPI as an Assistant Professor of Mechanical Engineering in 1970. He has served as the Director of the Aerospace Engineering Program, Department Head of Mechanical Engineering, Assistant Provost for Multi-disciplinary Affairs, Dean of Graduate Studies & Research, Dean of Academic Affairs, and is currently Associate Provost for Academic Affairs. Professor Durgin's research focuses on fluid mechanics with applications to environmental transport, nuclear reactor safety, aerospace dynamics, hydrodynamics, and low gravity fluid mechanics. He helped establish project centers in these areas providing students opportunity to conduct interactive and major qualifying projects of disciplinary importance.