ChE *learning in industry*

This column provides examples of cases in which students have gained knowledge, insight, and experience in the practice of chemical engineering while in an industrial setting. Summer interns and coop assignments typify such experiences; however, reports of more unusual cases are also welcome. Description of analytical tools used and the skills developed during the project should be emphasized. These examples should stimulate innovative approaches to bring real world tools and experiences back to campus for integration into the curriculum. Please submit manuscripts to Professor W. J. Koros, Chemical Engineering Department, University of Texas, Austin, Texas 78712.

WPI PROJECTS GLOBALIZE ENGINEERING EDUCATION IN THE PACIFIC RIM

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American trade to and from the Pacific Basin currently exceeds trade with any other region, and in fact, by hosting a recent APEC Forum in Seattle, the Clinton Administration publicly recognized the rapidly growing importance of Asian markets to the U.S. Professional education with any stake in the future has to be linked with Asia. The crucial question is "how"? Ideally, American universities should prepare their engineers to be fully competent both technically and socially in any part of the globe, but the reality of mastering two such disparate and intensely demanding disciplines as engineering and Asian language and culture presents severe barriers to achieving this kind of undergraduate training.

WPI'S PROJECT PROGRAM

Worcester Polytechnic Institute (WPI) addresses the problem of preparing engineers for global careers through a project program. Since 1865, the faculty and students at WPI (the nation's third oldest private technological university) have been keenly aware of the educational value of projects; working on real-world problems (often originated in industry) provides students with the motivation and discipline that are too often absent from passive classroom experiences. Projects have become the cornerstone of an innovative educational program known as the "WPI Plan," which was developed and implemented in the early 1970s. In addition to course requirements and a final project in the humanities, every student must complete two nine-credit-hour projects: the first in the student's major field (the Major Qualifying Project, or MQP), and the second on a topic relating society and technology (the Interactive Qualifying Project, or IQP).

The experience gained from off-campus projects over the past twenty years provides opportunities for WPI to apply the project approach to globalization in engineering education. Projects can be completed by a full-time commitment

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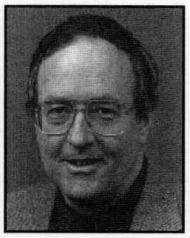

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of one term of seven weeks, so students can obtain a concentrated two-month experience in a foreign country during one of the five terms in the Institute's calendar (two in the autumn, two in the spring, and one in the summer). The IQP, with its emphasis on the importance of students becoming aware of the relationship between technology and society, forms the basis of the WPI global program.

IQPs, which in many cases are supported by professional organizations, industry, and/or government, are usually open-ended, real-world problems illustrating ways in which science and technology affect societal structures and/or values. Students thus learn very effectively the ambiguities and trade-offs that characterize problem solving beyond the textbook and introductory stage.

WPI'S GLOBAL PERSPECTIVE PROGRAM

The global economy, driven by technological innovations and competition for financial, material, and human resources, demands trans-national interdependence for scientists and engineers who will be confronted as never before with problems whose solutions require not only technical knowledge but also a knowledge of cultures other than their own. Yet, ironically, the United States as a nation provides few opportunities and little encouragement to engineering and science students to learn and understand other cultures, languages, and nations.

To provide opportunities for all WPI students within the usual four-year BS program and to allow students to learn about working in cultures new to them, WPI faculty launched the "Global Perspective Program" in 1989 with projects and courses concentrating on global issues. Because all faculty at WPI (engineering, science, management, humanities, and social sciences) advise and co-advise IQP projects, students are exposed to differing professional points of view and often see engineering faculty as role models in terms of concerns and analyses of social issues. This faculty commitment to a flexible, project-based curriculum makes it possible for WPI to send over two hundred undergraduate students abroad every year (roughly one-third of each graduating class). Unlike most international programs, WPI minimizes the costs of study abroad by charging no extra fees for the program, extending full financial aid as allowable by regulations, and securing highly competitive room-and-board rates overseas. The Institute even waives on-campus room-and-board fees when students are carrying out their global projects.

Through a combination of reciprocal exchanges (where undergraduate and graduate students can spend a defined period of time at a partner university under a tuition waiver) and residential project centers (where teams of students with a full-time WPI faculty advisor in residence carry out projects), WPI has created an extensive network of global opportunities in Europe, Latin America, and Asia (see Figure 1). While the challenges of cultural and linguistic adjustment are nowhere greater than in the Pacific Rim, WPI recognized the enormous technical and financial growth and potential in this region. Thus, with the help of alumni and corporate contacts, we have established residential project programs in Taiwan, Thailand, and Hong Kong, and are exploring possible new sites in Viet Nam, Japan, and China.

Students who want to participate in one of these three Asian residential project programs have to apply for admission to the program through the Global Program Office. After a competitive selection process, groups of two to three

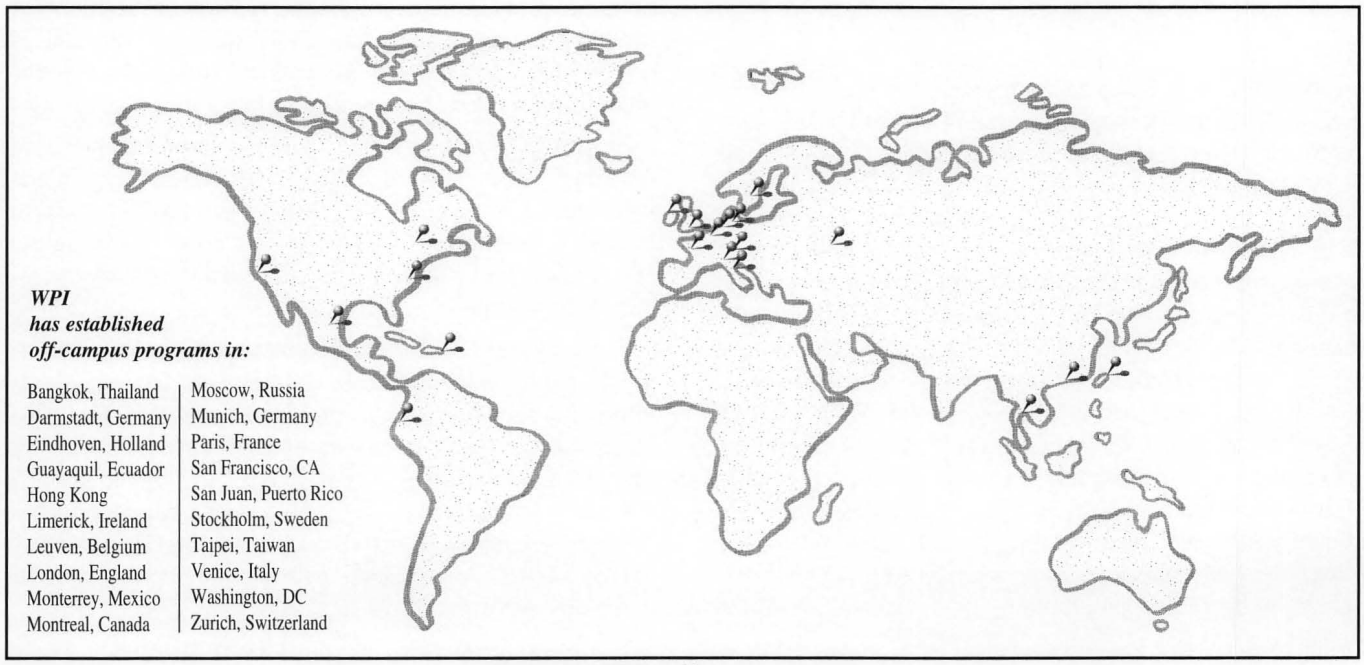

Figure 1. *WPI's off-campus centers.*

students are formed, either among the students themselves or by the staff of the Global Program Office. Generally, one or more students of Asian descent are paired with one or more non-Asian students.

The WPI faculty who serve as on-site program coordinators elicit project topics from participating industrial, governmental, or educational project sponsors. Then, from these topics, the student groups choose a project to work on. During the term prior to their departure, the students must take an independent study course designed specifically to prepare them for their overseas experience. This preparation involves a mix of three activities: academic, linguistic, and cultural. All students must complete a formal project proposal, to professional expectations, on the topic they will work on full time while at the foreign residential site. Working from letters of intent supplied by the sponsors, the students conduct a formal Literature Review (normally involving some direct telecommunications with the sponsors) as well as laying out a Procedures section, a Budget, and a Time Line for the proposed activity. In addition, depending upon the students' backgrounds, they must devote attention to gaining some linguistic proficiency for the country they visit as well as some appreciation of its historical and cultural background.

DEVELOPING THE PROJECT PROGRAMS IN ASIA

Probably the most difficult task in the overseas project program is developing a list of educationally sound projects of interest to sponsors in each host country. Since this paper focuses on WPI's programs in the Far East, we will describe the procedure for project programs in Asia.

Establishing connections before the program begins is especially urgent in the Far East. Through the assistance of local WPI alumni and contacts arranged by one of the authors (YHM), the Dean and Associate Dean of Undergraduate Studies (LS) visited Hong Kong, Thailand, and Taiwan in 1990 to investigate the feasibility of establishing project programs in the Pacific Rim. A subsequent visit by the first author, followed by a joint visit by both above authors, established local contacts with professional societies, industries, government agencies and universities. (Subsequently, another author [JFZ] was appointed Director of WPI's Asian program.) Two local project coordinators were also appointed: a chemistry professor at the Chulalongkorn University became a WPI Adjunct Professor and the project coordinator in Bangkok, and a chemical engineering professor was named in Taiwan. Both appointees are WPI alumni with a good understanding of WPI's programs. Their superb service and supervision were indispensable to the success of the project program.

Our concerns that few US students not of oriental descent would be able to learn Chinese or Thai were assuaged by the warm support we found along our alumni in these countries and by the fact that English is widely used in professional circles around the globe (especially in science and technology). Further, the concepts of project-based education we developed in Worcester were well received by the professionals we met. They shared our vision that American students would most readily learn to do professional-level work in a new culture through real-world projects with a bilingual staff, rather than being relegated to passive language and learning experiences in a classroom.

We faced several hurdles in the development of actual projects. First, many Asian cultures have reservations about undergraduate's capabilities, and second, substantive links between industry and academia at the undergraduate level have not been developed. But at all three sites, the services and flexibility of alumni were crucial in addressing the initial risks of offering a project for students who need to show more independence and maturity than their Asian counterparts. Nonprofit organizations in need of help at all levels, university researchers, and joint Asian-American enterprises were all most receptive to the project concept.

WRESTLING WITH BANGKOK'S RECYCLING NEEDS

In 1993, a group of three students, supervised by WPI chemistry faculty in Bangkok, undertook a project to examine the feasibility of recycling plastic, thus alleviating part of a garbage disposal problem in the slum area of Klong Toey. The students worked under the auspices of the Duang Prateep Foundation, renowned for improving life in the slums of Bangkok. The on-campus preparation work included examining different plastic recycling technologies and their economics. From the preparative work, the students learned that recycling programs are location-specific due to differences in available resources, city government structures, and attitudes of local citizens towards recycling.

Research for information on local environmental and recycling issues led not only to the records kept in the two major libraries, but also to interviews with key local people with interests in the plastics recycling program and to academic, industrial, governmental, and non-governmental organizations.

The students offered three recommendations: first, educating the public about important environmental issues; second, improving the separation of plastics wastes; and third, fostering better cooperative government/industry interaction. Specifically, the students urged changes that would provide a monetary incentive to individuals for separating the wastes prior to bringing them to the collection crews, thus improving the separation efficiency and maximizing the benefits derived from the other two suggestions.

The recommendation report has been distributed to the appropriate organizations in Thailand, including the faculty

at the Chulalongkorn University, governmental agencies, industrial groups, and non-governmental groups. WPI's local coordinator is following up the responses to the report and identifying opportunities for new projects in this crucial area.

CHEMICAL PROCESS SAFETY IN TAIWAN

A second group of four students (one Chinese speaking and three non-Chinese speaking) studied chemical process safety in Taiwan. The Chemical Engineering Department of the National Central University sponsored the project, and one of its faculty served as the on-site supervisor working with Professors Ma and Zeugner.

A by-product of the rapid economic growth experienced in Taiwan over the past forty years is a lagging effort in the areas of environmental legislation and industrial hygiene. This project examined the impact of the discrepancy between industrial progress and environmental safety within the framework of Chinese culture and specifically studied the level of safety, environmental protection, and industrial hygiene in the Taiwan chemical industry. The interactions between chemical plants and the surrounding communities, the employee and contractor attitudes, and the government/industry interactions were examined, leading to the definition of the associated problems facing the Taiwan chemical industry.

Prior to their departure for Taiwan, the students gathered extensive information and background on commonly used hazard identification and evaluation procedures. They also visited a major US chemical company and discussed safety practices with the company's safety officers. The knowledge they gained served as the basis for a comparison of safety practices in US and Taiwan chemical companies. In Taiwan, the students (accompanied by a chemical engineering professor who is also a leader in chemical process safety) visited six chemical companies. Each visit consisted of two to three hours of interviews with safety management personnel, followed by a plant tour. These visits formed the basis for their final analysis, which included the evaluation and general discussion of each company's emergency response, safety management, and training and safety review.

The students' analysis included the results of their study on the community's attitude toward chemical industry safety. They concluded that communities are more interested in seeking financial settlements than they are in demanding improvements in the chemical process safety. Facing the pressure of financial settlements, the companies are beginning to resist financial compensations and instead are reaching out to the public to discuss the safety aspects of their operations. Although Taiwan's central government is proceeding at a rapid pace to establish rules for chemical safety, cooperation between the governmental regulatory agency (Environmental Protection Administration) and the chemical industry which they plan to regulate clearly needs improvement. The students also suggested that Taiwan's universities strive to offer broader curricula in the areas of risk assessment techniques such as HAZOP, fault trees, and checklists, along with education in engineering ethics. Finally, they recommended the development of a set of "Guiding Principles" and "Codes of Management Practices" by the Petrochemical Industry Association of Taiwan to provide guidance.

CONCLUSION

WPI's Global Project Program provides a two-month project exposure to both technical and social issues in an Asian setting. Working side by side with Asian professionals, living in Asian cities, and using local transit to commute to work, all serve to challenge students to adjust quickly to the demands of being productive in a new environment.

The students at each site found that they were functioning not as guests, or even as consultants, but were more like full-time employed residents. Obstacles such as difficulties in data collection, confusion during interviews, and technical incompatibility in word processing had to be overcome quickly, even as the adjustments to different food, work habits, values, and assumptions were being faced simultaneously—just as real professionals would have to do. Most students found adjusting to the pace of a different culture both exhilarating and exhausting. While learning a new language to professional standards was not part of the program expectations, students made the most of opportunities to learn to negotiate in a different culture. One young woman, for example, celebrated her grounding in Asian culture by concluding her experience with a solo train trip from Beijing to Hong Kong.

The sponsoring agencies also reported benefits. Every project must be fully documented to professional standards by the end of the two-month stay. Agencies found the fresh points-of-view of students helpful, especially on issues where students could gather data that sources were reluctant to share with professional peers. And sponsors soon discovered that there were unexpected outcomes and payoffs in these projects; undergraduate curiosity often prompted cross-departmental and cross-agency communication that had not been possible before.

Our program in the Pacific Rim is barely five years old, and we await with intense interest its results. A social evening two years ago brought together the first two dozen or so students who had been our project pioneers in Asia. To a person they testified that nothing else in their education had been as meaningful as these projects that tested their ability to decipher complex societal and technical issues in a culture new to many of them. We look forward to their professional success as they return (as many stated they would) to the Pacific Rim to participate as professionals and as citizens. ❐