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.

EPIC

The Engineering Program for International Careers

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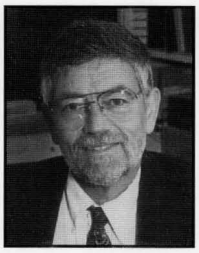
Competition in the world marketplace demands that the US educational system produce engineers who possess not only first-rate technical skills, but who are also capable of functioning effectively in a global engineering/industrial environment. American engineering education is world-class in the technical arena, but it has slighted the preparation of its graduates to compete in a global engineering arena. For many years the economic dominance of the US in the world economy permitted us this luxury. Development of the European and Pacific Rim economies, however, has brought us into a new era. Now, for example, three of the five largest chemical companies in the world are German, and only the fifth largest is US-owned. Perhaps more important, manufacturing and engineering companies have become multinational in their operations. The design of new vehicles or chemical plants involves teams spread across multiple continents. Moreover, US engineering graduates often compete with engineers educated abroad for positions in this global engineering/industrial arena. European and Asian engineers commonly speak multiple languages and have broad international experience, while neither of these attributes is typical of US engineering graduates.

The growing need for US engineering graduates who are prepared to work in this international environment has not gone unnoticed. For example, a workshop addressing international engineering education issues was held by the Fund for Improvement of Post Secondary Education in 1990.[1] In 1992, the National Science Foundation sponsored workshops to address US-German interaction in engineering research as well as in education.[2] Representatives of German industry emphasized the need for US engineering graduates prepared to function professionally in Germany (or other European countries). The primary issue is not placing US engineers in permanent positions in Europe, but short-term assignments and interactions between US engineers and coworkers (or customers) from other cultures. Specific requirements cited included foreign language proficiency and experience in engineering work or study in a foreign culture.

U.S. schools have responded to this need in various ways. For example, Michigan State has long offered a summer course taught by MSU faculty at the Rheinisch-Westfalische Technische Hochschule in Aachen, Germany, and they now offer academic year exchange with RWTH. Rhode Island offers a unique dual-degree program (BS Engr/BA German),



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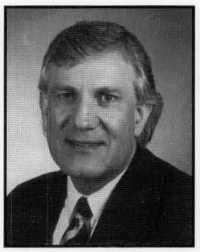

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and Cincinnati has an International Engineering Co-Op Program with an internship abroad. Various engineering colleges (*e.g.,* Rose-Hulman, Wisconsin, and Rhode Island) offer exchange programs with specific foreign schools, and study abroad through the International Student Exchange Program is widely available. Still, engineering student participation in study abroad remains small, influenced by cost, course transfer, and foreign language proficiency issues.[3] The American European Engineering Exchange Consortium (AE^3) of over thirty-five American and European institutions has recently been established to promote international education in engineering. AE^3 will address transfer and other issues and offer programs that include both study abroad and internship opportunities.

PROGRAM CONCEPT

The need for this international dimension is certainly evident from Clemson's perspective. Consider that 160 foreign-owned companies have US headquarters in South Carolina. In 1993, there were 457 international facilities in the state, 70% of which are located within fifty miles of Clemson University. Adding to this international flavor are numerous US-owned global manufacturing and engineering concerns in the area. In responding to the obvious need to enhance the international component of its undergraduate programs the College of Engineering had to address the following key problems:

- *Although there is some recent improvement,[4] few US secondary school graduates have more than a passing knowledge of a foreign language; this is especially true with respect to some languages important from an industrial viewpoint (e.g., German, Japanese).*
- *Many engineering students come from middle- to low-income families. Thus, significant additional costs to the student would limit the number of students electing the program.*
- *ABET and institutional general educational requirements constrain curriculum content.*
- *Many engineering students are unaware of the implications of economic globalization.*
- *At Clemson (and many other institutions), engineering students select a specific major at the end of the first year. Thus, program entry after the first year should be accommodated.*

Considering these factors, the EPIC program was developed based on the following principles:

- *The program cornerstone is a company-sponsored International Internship of significant duration in the foreign environment. This approach minimizes costs to the student and provides a particularly valuable form of international experience. As an option, the program offers a study-abroad period to complement and extend the internship experience.*
- *At least three years college-level study of the foreign language, including a period of "immersion" language and cultural preparation just prior to the overseas internship.*
- *Prior to the international internship, the program requires at least one domestic internship to provide experience in the engineering work environment.*
- *The program provides continued exposure to the foreign language following the overseas experience and includes courses addressing global culture and economics.*
- *Industrial guidance in development, evaluation, and operation of the program is provided through an Industrial Advisory Board.*
- *A Certificate provides a credential for students completing the program.*

PROGRAM DEVELOPMENT

Recruitment of Industrial Partners • The most critical early activity in the project was recruiting companies to participate in the program and to provide the international internships that are at the core of EPIC. Indeed, despite the discussion at the NSF workshop and with other corporation representatives, the question of the real level of interest by the corporate community remained open—would there actually be sufficient corporate support to make the program viable? Corporate response to EPIC definitely answered this question in the affirmative. To date, fourteen companies have joined the program and are represented on the EPIC Advisory Board. Moreover, company representatives on the EPIC Board are unanimous in the view that there is a real and growing need for engineers prepared to function in an international environment.

Program Structure/Curriculum • The program structure outlined above was developed with the close collaboration and approval of the EPIC Board. Additional features are:

- *Entry into EPIC requires completion of all freshman requirements with a grade point average of at least 3.2, and registration in first-year (or higher) language courses.*
- *EPIC internships are arranged by US operating companies (either US or foreign owned).*
- *The selection process includes interviews of student applicants by EPIC companies.*
- *The overseas internship is scheduled after students have completed most of their junior-level engineering courses.*
- *Language options include French, German, and Japanese. This is based on the overseas internship opportunities with the current sponsoring companies.*

A "typical" EPIC program schedule incorporating these features is shown in Table 1 (next page). In terms of academics, the primary change is incorporation of twenty foreign language credits. Many of these credits can qualify as electives within the base engineering curriculum. Clemson curricula, for example, include several "free" elective credits plus 16-18 credits of humanities and social sciences, allowing up to 14 language credits to qualify as electives within the curricula. However, EPIC does require about six "excess" credits, equivalent to the credits in the intensive lan-

guage course. As in the case of co-op payments, the inclusion of two internship terms results in a total program duration of five years.

The EPIC entrance requirement is set reasonably high (GPA > 3.2) to assure that students have a good probability of meeting the academic demands of the program. While academic credentials are significant in company assessments, personal attributes such as self-reliance, resourcefulness, flexibility (*i.e.,* ability to cope with new situations), and willingness to take risks are also very important in evaluating candidates. In addition, factors such as vision/ambition, communications ability, leadership, and interpersonal skills are important as in any professional hiring situation. Judgments on these factors are subjective, and thus the interview process is highly important to the participating companies, with many of them conducting follow-up interviews at plant sites after an initial on-campus interview.

The program structure will be reviewed and revised as experience is gained. For example, alternative schedules with two or more domestic internships have been developed to suit the desires of some EPIC companies.

Student Recruitment • With the program structure established, student recruitment began in March of 1993. Clemson freshmen enrolled in engineering were given information on EPIC, and follow-up contact was made via a survey designed for use in program evaluation. The survey indicated that less than 20% of freshmen engineering students at Clemson have any interest in a career involving international assignments, and even fewer expressed specific interest in EPIC. Virtually identical results were obtained in a survey conducted in the spring of 1994. These results clearly indicate the need for greater emphasis on language, international culture, and globalization in our curricula. Programs like EPIC address this issue both directly (by increasing the number of students having international experiences) and indirectly (through the presence of more engineering students on campus who have had international experiences).

Ten students with the requisite qualifications applied for the first round of interviews held in November of 1993. The small number reflects the survey results noted above, plus the newness of the EPIC program. In addition, only four EPIC companies were available to interview in the fall of 1993. Due to the small number of both students and companies, some companies had no applicants to consider in their desired language/major combinations. Similarly, some students found no companies interested in their language/major. As a result, only two students were placed. These students had domestic internships in 1994-95 and will have overseas internship in fall 1996.

Augmenting this, BMW (whose U.S. plant was under construction) selected two senior-level students for internships in Munich beginning in the summer of 1994. These two BMW internships were invaluable in that they provided immediate experience with sending students abroad. As it happens, one of the students had co-op experience (but minimal German), while the second was fluent in German (but had no prior engineering work record). Both had fine experiences (despite a few rough edges due to their "pioneer" status), and BMW was pleased with the overall performance of both students. However, BMW concluded that future interns needed to have both prior work experience and good German competency, thus confirming the need for both of these components in the EPIC program design.

The second round of EPIC applications was held in the fall of 1994, with twenty-one qualified students (including one from the University of North Carolina at Charlotte, another SUCCEED school) applying to join EPIC and nine companies participating in the interviews. This represented a significant increase in both applicants and participating companies. Still, the unbalanced distribution of language/major combinations again hampered placements. In March of 1995 an additional round of interviews was held in which freshmen were permitted to interview for the first time. The purpose of this was to enable students considering co-op opportunities to simultaneously consider EPIC (previously, students were required to have completed the entire freshman year). Five companies and ten students participated. In addition, BMW selected a third senior student (a Chem E with co-op experience and excellent German) to send directly to Germany. The student reports that he is having a fine work experience and is enjoying Munich greatly, while BMW is extremely pleased with the performance of the student and his preparation for the assignment. EPIC student participation now totals fifteen, with Fall 1995 selections under way.

Operational Factors • The financial terms for the intern-

TABLE 1
Typical EPIC Program Schedule
(Italics denote EPIC-specific components)

First Year	Standard freshman sequence	~32 cr
Second Year	*Interviews with EPIC companies*	
	Two semesters foreign language (first year)	8 cr
	Balance of "normal" sophomore courses	~26 cr
Third Year		
Fall	*Industrial internship in US*	
Spring	*Third semester of language*	3 cr
	Normal first-semester junior classes	~15 cr
Summer	Normal junior classes	6 cr
	Intensive language institute	6 cr
Fourth Year		
Fall	*International internship (4-6 months)*	
Spring	*International social science elective*	3 cr
	Normal second-semester junior classes	~12 cr
	(optionally Spring semester abroad at foreign institution	
Fifth Year	*Upper division language course*	3 cr
	International social science elective	3 cr
	Balance of normal senior year sequence	~27 cr

ships are of considerable practical importance to the students. The agreement reached by the EPIC companies is that they will compensate EPIC students at the same rate as their normal practice for co-op students and summer interns. However, for international internships consideration will be given to cost of living, travel, taxes, etc. In this regard, the EPIC companies agreed to provide round-trip transportation to the host country and to address the key cost of living issue by assisting the students with housing arrangements. As a general rule, the goal is for the participants to "break even" during their international assignment.

Issues such as visas, work permits, residence permits, and tax regulations for international workers need to be addressed before arrival in the country. For instance, in Germany an internship's duration has a major effect on the income tax liability, with substantially higher tax liability for internships exceeding six months.

Evaluation Plan • As with any project, it is important that the EPIC program be assessed to determine its effectiveness, to follow up on the question of whether it is meeting a real need, and to provide information for use in improving the program. Data gathered from successive entering classes, and follow-up data from graduates, will enable assessment of the impact of EPIC in altering the international perspective of engineering students. Data from employers, EPIC students, and EPIC graduates will be used to evaluate and improve the EPIC program. Obviously, gathering these data will be a multi-year undertaking.

Study-Abroad Linkages • Discussions regarding enrollment of EPIC students in engineering courses in the semester following their internship have been held with German and French schools. All indicated an interest in having US students enroll and expressed a willingness to assist the students with housing, exam arrangements, etc. Details of course equivalencies will have to be worked out for each major and each institution.

Development of the Language Institute • The initial offering of the institute was in July-August 1995. The institute is tailored to students with technical backgrounds who have completed basic study of the language. The institute is specially targeted at meeting the needs of engineering students about to embark on an overseas internship, bringing them from basic language understanding to a reasonable level of conversation, including an introduction to appropriate technical vocabulary.

IMPLEMENTING EPIC AT OTHER INSTITUTIONS

We certainly encourage others to borrow any or all of the EPIC scheme. The key steps to doing so are fairly simple:

- *Identify a core of enthusiastic supporters from international companies that have strong ties to your school, and invite them to form the charter membership of an advisory board for your international engineering program.*
- *Lay out a "curriculum" for the international program that shows students (and companies) how the necessary language courses and internships fit into a program of study.*
- *Identify a mechanism to provide an "immersion" language program prior to the overseas experience.*

The first item is clearly the most important if the EPIC concept of providing international experience through internships is to be used. Enthusiastic supporters will help "make things happen" within their own companies and can help in recruiting additional industrial partners. The curriculum plan is important as a way of conveying to the students an orderly way through the program. Finally, it is our view that an immersion program is an essential part of the language preparation. Of course, it is not practical for every university to offer such an immersion program. However, existing programs in the US (such as the Clemson program) or abroad (*e.g.,* the Goethe Institute in Germany) can be used.

CONCLUSIONS

Corporate interest in EPIC confirms the need for an international dimension in US engineering programs. It has been well received by students since it addresses a key issue (cost) that prevents some students from pursuing other international education programs. Our experience to date clearly shows it to be important to have a critical mass of companies and students so as to minimize supply/demand imbalances in the various major/language combinations. It is pertinent to note that the demand for chemical engineers has exceeded the supply in both German and French, while the ChE supply/demand picture in Japan is "perfectly balanced" (no applicants and no positions!).

Overall, our experience validates both the premises upon which EPIC is based and its practicality in terms of meshing with existing engineering curricula. Coupled with the strong company and student interest, this indicates that EPIC is a viable model for similar programs at other institutions.

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REFERENCES

1. "Internationalizing Engineering Education: A National Workshop," FIPSE, Washington, DC (1990)
2. Workshops on "US-German Cooperative Programs in Chemical and Mechanical Engineering," NSF, New Orleans, LA (1992)
3. "Open Doors 1994-95," Institute for International Education, New York, NY (1995)
4. Draper, J.P., "Foreign Language Enrollments in Public Secondary Schools, Fall 1989 and Fall 1990," Am. Council on the Teaching of Foreign Languages, Yonkers, NY (1991) ❐