International Exposure for Engineering Students Using Distance Learning Techniques

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Abstract

A new mechanism is being developed for expanding international exposure for undergraduate engineering and computer science students in the United States, using information technology and distance learning techniques. Technical students in the United States, in a few instances, have begun working on projects with similar students in other countries via electronic communications. This paper provides a rationale for having engineering students gain some international experience during their undergraduate educational periods, and points out barriers to getting such experience in traditional study abroad periods. It then cites several academic programs that are providing such experience via electronic means. Finally, the authors present a proposed direction to increase the use of distance learning techniques to provide international experience for American engineering students.

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I. Introduction

Russel Jones did a major study a few years ago entitled "Educating Engineers for International Practice." That study, which was published in *Liberal Education* in the fall 1995 issue, argues for the need for extensive international exposure for United States technology students to adequately prepare them for international practice [1]. It is the conviction of the authors of this paper that such exposure is needed to keep the United States engineering base competitive in an increasingly global marketplace. That need has only increased since Jones' earlier study was completed – yet we see too little movement toward better preparing college graduates for the international challenge.

Constraints such as the intensity of the undergraduate program for engineers and the lock-step progression through the four or more years of study weigh heavily against engineering students taking advantage of traditional study abroad experiences. Traditional study abroad or internship programs also tend to be quite expensive, again limiting the number of engineering students who can or will participate. It should be noted, though, that several engineering schoolsare conducting exemplary programs based on the studies abroad model of sending students overseas. Examples of these programs will be described later in this paper. But such effective programs currently have much too little impact when the 300+ engineering schools in the United States are taken as a whole. In its annual survey of student mobility, published in *Open Doors 2001*, the Institute of International Education reported that only 4,139 United States engineering students had a studies abroad dimension in their education – representing less than 3% of the U.S. study abroad students, and an even smaller percentage of the current number of engineering students in the undergraduate pipeline [2].

It is also relevant that other developed countries – such as those in Europe – prepare their engineering and computer science students for international practice very effectively. As pointed out by Simpson in 1997 [3]: "Russel C. Jones article entitled 'The World as Workplace' in the November 1996 edition of the ASEE journal presents a policy which is being tried in Europe for a decade now."

Knowing that engineering and computer science students need more international experiences, and aware of the barriers usually present in traditional study abroad programs, a few engineering schools have begun using information technology and distance learning techniques to provide some international exposure for their students. Such efforts are aimed at overcoming some of the major barriers of study abroad such as high cost, the constraints of a highly sequenced curriculum, and the concern of faculty that their control of the educational process may be lost.

II. Driving Forces for International Exposure for Engineers

Many educators and practitioners have stated the need for international exposure for engineering students. In 1980 at a conference on New Directions in International Education, Burn and Perkin argued that "Expertise on the rest of the world is needed as never before in government, business, and especially in the universities. … Increasingly needed are specialists who combine foreign language training and international studies expertise with training in professional fields …" [4].

More recently, Condit and Pipes [5] have stated "The changing needs of an industrial world create a corresponding need to improve and restructure higher instructions, particularly that of engineering education." Pelkie [6] has written "Global competition has become a business reality. To become competitive, we must improve the rate at which new technical concepts are incorporated into our products and processes. … Managers must recognize the impact that the technical education system has on future innovative productivity and take the initiative to improve it." Fiedler *et al* [7] have argued that "Computer based information systems have altered the meaning of traditional communication and coordination, making global opportunities possible and global competition inevitable."

III. Study Abroad Programs

Engineering schools at several U.S. universities are conducting exemplary programs based on the traditional studies abroad model of sending students overseas. Worcester Polytechnic Institute (WPI), which requires a major project of each student prior to graduation, has an increasing number of such students fulfilling that requirement with an international educational experience. Massie and Zwiep [8] point out that " Project work in a foreign country provides a reasonably pragmatic way for students to gain international experience." Mello [9] further describes how the WPI program emphasizes multi-disciplinary teaming, professional and ethical responsibility, communication competence, and a real understanding of the impact of solutions in a global and societal context.

The University of Rhode Island (URI) offers an even more intense international program for its engineering students, combining language study in a foreign language, courses on the home campus in that foreign language, and a work period abroad for an integrated international experience. Grandin [10] describes the URI program, which culminates in joint degrees in engineering and a foreign language.

Van Gulick and Paolino [11] have described two key features which serve to internationalize the Lafayette College undergraduate engineering curriculum: semester-long abroad study opportunities in all B.S. engineering degree programs; and a five year, two-degree program in which B.S. engineering students acquire in-depth knowledge of a foreign language and culture and complete a semester-long capstone experience working abroad as an engineer during their fifth year. A unique feature of the Lafayette programs is the use of two-way video conferencing to offer necessary technical courses to students abroad.

In 1983, the University of the Pacific started sending its students to Japan for their co-op placements. Based on the experience and a similar program in Germany, a structured program for preparing students for such international co-op experiences has been instituted. Martin [12] describes how the university has made available a plan whereby students can take internationally-oriented courses prior to their co-op periods abroad, and receive an "International Engineering Minor" degree upon completion.

One of the most encouraging developments in educating U.S. engineers for international practice is the Global Engineering Exchange (Global E^3), administered in the U.S. by the Institute of International Education and in the European Union (EU) by GE^4 [13]. Global E^3 focuses mainly on U.S. undergraduate engineering students. Students in the Global E^3 program spend one or two semesters studying at a member institution overseas, paying tuition at their home institution only. The host institution provides students with intensive language and culture training. In addition to formal study, Global E^3 encourages overseas internships as part of its program. In some five years of operation, the Global Engineering Education Exchange Program has grown to over 200 exchanges annually, involving over 80 major engineering schools throughout the world [14]. Unfortunately, the number of U.S. engineering students studying abroad has lagged behind the number of foreign students coming to the U.S. for study.

Many other engineering programs offer variations on the type of traditional study abroad programs described above. It must be kept in mind, though, that in the aggregate less that 2% of engineering students in the United States currently partake of such programs.

IV. European Competition

As noted earlier, some of the economic competitors of the United States in the global marketplace are currently more effective in preparing their engineering graduates for international practice. In the EU, the European Commission's Erasmus program provides mechanisms for the cross-border study of a large number of students, including engineering students. Groups of universities have agreed to cooperate in Thematic Networks. A body called Higher Engineering Education for Europe (H3E) was created to manage the Thematic Network in engineering [15]. One of the projects of H3E is the development of a European dimension in higher engineering education.

Anderson [16] describes a European semester concerned with international student teamwork, which has involved some 200 engineering students from 14 countries since 1995. The semester-long product development experience has proven to be an effective way to develop students' international awareness alongside their enhanced technical skills.

Weber [17] describes how engineering schools in Europe are co-operating to develop a common definition of qualifications needed by an engineer today. He notes that there is a growing convergence in adopting English as the language of engineering instruction. Augusti [18] writes that the rapid globalization of the professional job market has created the need for an international system of recognition of degrees. The Bologna Declaration is driving toward harmonization of degrees across Europe, and will certainly lead to more cross-border student mobility.

The European model for international experience for engineering students is based on the traditional study abroad movement of students. That approach appears to be highly successful there due to the relatively short distances between countries, and the overarching framework provided by the European Union.

V. Distance Education

Mechanisms for student-to-student interaction across U.S. institutions have been developed and utilized by some of the Coalitions funded by the National Science Foundation. The Synthesis Coalition in particular has featured the development of electronic tools to facilitate joint work by student groups on campuses thousands of miles apart. Hsi and Agogino [19] describe the use of such advanced multimedia communication mechanisms to teach engineering design across campus borders, utilizing well-developed case studies. Gay and Lentini [20] further describe the advanced communication resources used by students engaged in collaborative design activity.

The use of the Internet has enabled both teachers and students to lessen the burden of disseminating and acquiring knowledge, according to Young [21]. Even laboratory experiences can be enhanced through electronic media. Karweit [22] has created a virtual engineering laboratory on the World Wide Web for the students in his introductory engineering class and others. Experiments in this simulated laboratory include one that measures the rate of a hot object's heat radiation, and one that enables students to design bridges that will bear a specific weight. Fruchter [23] has used information technology augmented distance learning to teach a multi-site, project-centered, team-oriented course.

A senior design distance-learning experience between U.S. universities is described by Enderle [24], where students at the University of Connecticut and at Ohio University collaborated on devices to aid persons with disabilities. The students used the WWW, videotape, video-conferencing, e-mail, and telephone to facilitate communications.

It is clear that information technology and distance learning techniques are available to facilitate in-depth interactions among students at distant campuses, including those across national boundaries.

VI. Pilot International Exchanges via Distance Learning Techniques

A small number of campus-based programs in the U.S. have been using distance-learning techniques to provide international experiences for their students. Programs of this sort have been developed at such engineering schools as Union College, Carnegie-Mellon University, Stanford University, Texas A&M University, and the University of Pittsburgh, for example.

At Union College, beginning with the class of 2000, all engineering students are required to fulfill an "engineering experience" requirement. As described by Bucinell *et al* [25], "The ever increasing globalization of engineering practice has led to the realization that undergraduate students must be made aware of the global nature of the profession and the technologies that allow engineers the world over to collaborate on projects." Union College engineering students can fulfill the international experience requirement by a traditional term abroad, an international exchange to take courses at foreign universities, an international term in industry, the virtual term abroad, or an international project. The Bucinell *et al* paper describes the development of an International Virtual Design Studio, wherein students from Union College and the Middle East Technical University (METU) in Turkey were joined as a team to pursue their senior design projects across international boundaries and culture differences. Using a combination of interactive video and Internet connections, the two parts of the team undertook a single design and build project, sharing databases and designs electronically. The team members met each other in person at the end of the project when they came together in Ankara to assemble the final design and participate in the design competition with additional teams from METU.

At the University of Pittsburgh, a novel format for an engineering design capstone course has combined industrial experience with international collaboration, and uses distance learning as a pedagogical tool. As described by Rajgopal *et al* [26], the course links programs in the Industrial Engineering Departments of the University of Pittsburgh and the Instituto Tecnológico y de Estudios Superiores de Monterrey in Mexico. The team of students from the two institutions conducts their design at an industrial location that alternates between Mexico and the U.S. each year. The two groups of students, and their faculty advisors, stay in touch by electronic mail, the Internet, and distance learning technologies. During the last week of the term, the full team comes together at the industrial location to present their work to the faculty and the industrial client.

Texas A&M University has employed reciprocal distance education to promote internationalization of its undergraduate engineering program. As described by Holland and Vasquez [27], the Architectural and Construction Science Program at Texas A&M uses a model containing three distinct components for adding an international dimension for its students: insertion of an international dimension at the syllabus level; integration of an international dimension at the curricular level; and immersion in a foreign instructional environment. The first two components rely on the Internet and videoconferencing technologies. The third component is a blend of traditional study abroad programs with international internships and reciprocal student exchange programs.

Stanford University and Tokyo Metropolitan Institute of Technology have shared a mechanical engineering design class, as described by Fukuda *et al* [28]. This cross-national border design experience has made students in both countries aware of international issues in design, and has sharpened their computer and communication capabilities.

Long-distance collaboration has also been developed between students at Carnegie-Mellon University and at Delft University of Technology in the Netherlands, as described by Herder *et al* [29]. Students have had to learn how to cooperate with people in another location and time zone, and with a different cultural background. A Web-accessible document management system facilitated capture, organization, and sharing of documents generated by anyone throughout the course.

Similar cross-national border collaborations have been developed between non-U.S. countries. Clear [30] describes design projects conducted by students at Auckland University of Technology and at Uppsala University. Projects involved collaborative software development and evaluation.

The North American Design Institute (NADI) is a partnership of governments, universities and industries across North America. As described by White [31], it involves two universities in each North American country – Mexico, the United States, and Canada. These institutions collaborate on a unique exchange program in engineering design to prepare engineering students to better understand design in the context of cultural, health, safety, environmental, and other international regulatory policies throughout North America. A combination of students traveling to partner schools for a semester, industrial work assignments, and interactions via the Internet and the World Wide Web are utilized.

VII. Conclusions

The driving forces for international experiences for U.S. engineering students are substantial, and traditional study abroad programs – while generally of desirable high quality – are having too little quantitative impact to meet the needs of the bulk of such students. Distance education methodologies offer the opportunity for engineering students to get international experience in a cost-effective yet highly useful way. Several engineering schools have developed pilot programs utilizing information technologies and distance learning methodologies to offer international experiences to students who are not readily able to travel abroad from their home campuses.

It appears that the time to begin scale up of the use of distance learning technologies to provide international exposure for larger numbers of engineering students is at hand. The authors [32] propose that a consortium of engineering schools be formed for this purpose. The activities of such a consortium would include:

– illumination of the current state of the art in the use of distance learning for international programs in engineering;

– development of central mechanisms for developing case studies which can be utilized by teams of international students;

– establishment of an electronic database to facilitate international matching of engineering schools with similar interests; and

– seeking funds to develop the central mechanisms described above, and for demonstration projects at several U.S. universities.

It is anticipated that after such demonstration projects, the central mechanisms developed would become self-sustaining.

Such a project would overcome some of the major barriers to study abroad, such as high cost, the constraints of a highly sequenced curriculum, and the concern of faculty members that their control of the educational process may be lost. It should, at steady-state, provide international exposure to significantly more than the 2% or so of U.S. engineering students currently experiencing it.

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