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Engineering the World

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ABSTRACT

Until recently, the humanities and social science fields were the ones primarily focused on encouraging students to participate in education abroad and international exchange programs. However, the science fields, such as engineering, are beginning to understand the importance of connecting students' global experiences with traditional curriculums as the world continues to flatten and the global marketplace relies more heavily on the brain and economic power of people from countries everywhere. This article highlights internationalization efforts in engineering education across the country.

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Why Internationalize Engineering Education?

In today's shifting and growing global economy, it's hard to image that current engineering graduates, regardless of their specialty, will not be interacting regularly with colleagues and customers from all over the world. It, therefore, becomes vital, according to Jan Helge Bøhn, associate professor of mechanical engineering at Virginia Tech, Blacksburg, to equip students with the skills to enable them to be effective in careers in the international arena. "International experiences give engineering students a foundation for life-long learning, opens their eyes to what lies beyond their current horizons, and prepares them to work, learn, and interact in a global engineering economy," he observed.

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Because engineering graduates are very likely to work on international teams performing research and development, design, manufacturing, etc., they need exposure to other cultures and languages during their undergraduate career to help them better understand cultural differences. "As engineers they may be going abroad on short business trips, be based in the U.S. but be working virtually with people in other countries, or even be given a long-term overseas assignment. By studying, interning, or working abroad and studying a second language during their educational years, students learn how engineering education and engineering projects are performed overseas and will become more attuned to what will be confronting them after graduation," said John Grandin, executive director of the German International Engineering Program and professor of German at the University of Rhode Island (URI), Kingston.

Raymond Wright, interim dean and professor of civil engineering at the College of Engineering at URI observes that many students don't go abroad or take language courses and are comfortable working domestically after graduation and being hired. "However, almost a quarter of URI's undergraduate population takes advantage of international educational opportunities. That is a good indicator that engineering students are recognizing the value of international internships and study abroad academic experiences to companies with overseas offices," he said.

Enabling future engineers to be more competitive in their chosen career is one of the prime reasons that engineering education has to be more internationalized, agreed Larry Shuman, professor of industrial engineering and senior associate dean at the University of Pittsburgh. "Trends indicate that a large chunk of engineering work is increasingly being performed overseas where it costs less to get the same quality. American engineering graduates will have to compete in this highly globalized job market where their future role will likely be as system integrators and project managers working with a diverse team of people. International experiences and exposure to other languages will provide them with the skills and

tools to work across cultures, whether face-to-face or in a virtual team over the Internet,” Shuman explained.

Becoming familiar with and understanding another culture’s approach to engineering design is one of the vital components of an international educational experience. “That is because it is the application of engineering concepts that is being globalized, not the technical aspects of engineering,” observed Jack R. Lohman, vice provost for Institutional Development and professor of industrial and systems engineering at the Georgia Institute of Technology in Atlanta.

However, according to Ramon Wyss, vice president for international relations and professor of nuclear physics at the Royal Institute of Technology (KTH), Stockholm, good engineering education has always had an international component since the problems faced by engineers are not restricted to national borders. “It is the development of a global corporate work environment that has accentuated the importance of internationalization,” he said.

Demand for Global Perspective

Any economy is based on the products that are being demanded, according to Bøhn. To meet the global demand, engineers must understand their customers’ needs, which are no longer restricted to domestic U.S. projects. “Over the past decade, the economy has become increasingly global and companies need engineers that can not only identify and extract customer needs, but do so in collaboration with overseas colleagues,” he said.

As the global economy has evolved, companies have established offices and plants around the world. That is what, according to Grandin, is driving the demand for engineers with a global perspective who can adjust to overseas environments. “Companies with overseas locations are increasingly demanding engineers with a global perspective and the international experiences that help make them more mobile, flexible, and willing to take risks,” Grandin explained. In addition, today’s communication technology, which has facilitated the growth of the global workforce, is enabling the shift of design functions overseas as the quality of foreign engineers equal those found in the United States and at lower cost, according to Shuman.

The global perspective being demanded by potential employers can be provided to students through international internships, study abroad experiences,

and engineering-focused volunteer programs. “International internships teach students about different cultures and approaches to engineering problem solving in an international context, and provide the opportunity to develop language skills,” said Cheryl Matherly, associate dean for global education and applied assistant professor of education at the University of Tulsa. And while education abroad experiences usually tend to focus more on cultural components, learning overseas does help students develop independence and interpersonal skills, both of which are necessary for professional development. A growing trend in providing a global perspective is through volunteer programs, such as Engineers Without Borders, where engineering students apply their technical skills to real-world problems. “Students can further their technical development by designing and executing projects, as well as develop their intercultural skills by responding to an overseas’ community’s needs,” she added.

Not only does a global perspective give future engineers an understanding of different cultures’ values, morays, and traditions, it makes them more effective businesspeople and better enables them to negotiate, supervise, and work side-by-side with others. “That understanding and improved effectiveness is why engineering firms are demanding a global perspective,” observed Annagene Yucas, director of the Study Abroad Office at the Center for International Studies at the University of Pittsburgh. In addition, the expectation today of many companies is that their engineers will be sent overseas at some point or work on an international project. “These companies feel that an engineer with a global perspective gained from past international educational experiences will be better suited,” added Michael Steinberg, executive vice president of academic programs at the Institute for the International Education of Students (IES) in Chicago.

A global perspective is also required for engineers to tackle worldwide problems related to food, water, climate, and sustainable global development. “An international, open education enables the development of curricula along the developing lines of our world,” observed Wyss.

How Internationalization Started and Where It’s Headed

The internationalization of the marketplace, according to Grandin, is what created the need for internationalizing engineering education in the first

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place. “Those universities and companies that recognized the need began advocating for international education 20 years ago,” he observed. And, according to Matherly, companies began questioning universities in the 1990s about the availability of international experiences for engineering students.

The effort to increase opportunities, though, is still in transition, according to Bøhn. “Schools are making international learning experiences more available, but engineering academia is generally still in the process of establishing its global presence.” A major force behind the increase of international educational opportunities is the criteria laid out in the ABET 2000 initiative (formerly known as the Accreditation Board for Engineering and Technology, the organization officially changed its name to ABET, Inc. in 2005), which say that engineers must be able to work in multidisciplinary teams and communicate well. “One of the major changes in the internationalization of engineering education since efforts began has been the requirement of accreditation bodies such as ABET for an international component in the curriculum,” confirmed Yucas.

Shuman observes that the difference between today’s internationalization efforts and yesterday’s is that yesterday’s didn’t exist. Historically, he says, the percentage of engineers who had an international education experience was close to only three percent. Today some of the schools leading the effort have up to 35 percent of their students taking advantage of international opportunities. “International experiences are becoming integrated into the engineering curriculum and have increased the focus on learning a second language.” And as the growth of available programs becomes more rapid, resistance will continue to lessen, according to Steinberg. “Institutions are now encouraging engineering students to have an international experience instead of making excuses to not offer the opportunity,” he said.

The future for the continued internationalization of engineering education is indeed bright, if what has been accomplished so far is any indication. For example, according to Bøhn, more college administrators are traveling around the world to establish relationships and programs with schools overseas. “Although there has been progress, these relationships are still in their beginning phases and only about two percent of engineering students have had a study or work abroad experience,” he cautioned.

At the same time, the existence of international educational opportunities has become an excellent recruiting tool for students that understand the need.

Matherly also sees good news in the progress that’s been made so far. She cited a 2004 study conducted by ABET on the impact made by the changes in its accreditation criteria for international education that reports that “four years after the implementation of ABET 2000, the first group of graduates had students that demonstrated more active engagement in their own learning, spent more time studying abroad, had more international travel experiences, that international programs had more emphasis on openness to diverse ideas and people, and that there was an increased awareness of societal global issues that can affect engineering decisions.”

Steinberg predicts that the progress made to date will only expand with more opportunities created, more programs introduced, and more students willing to study overseas. “The federal government has recognized the need for internationalizing education by recommending scholarship support for international study in many fields, including engineering,” he reported. For example, the Benjamin A. Gilman International Scholarship can provide awards for U.S. undergraduate students to participate in study abroad programs worldwide. The David L. Boren Undergraduate Scholarships for Study Abroad from the National Security Education Program offers opportunities for U.S. students to study in world regions critical to U.S. interests, but that are generally underrepresented in education abroad programs, and the report of the Commission on the Abraham Lincoln Study Abroad Fellowship Program makes detailed recommendations for a national undergraduate study abroad fellowship program to dramatically increase and diversify study abroad participation in the United States.

Other predictions for the future of internationalized engineering education include more collaboration between U.S. and foreign universities that bring U.S. students and their overseas peers together to work on projects, the development of more programs that include creative and nontraditional opportunities, an increased focus on offering more languages such as Chinese, the establishment of campus centers overseas to facilitate students’ working and studying abroad, and the exchange of large blocks of U.S. and foreign students. Observed Yucas, “When having an international educational experience becomes a requirement in the engineering curriculum, that’s

when we'll see the shift to a greater number of participants."

The importance of continuing efforts to internationalize engineering education is considered obvious by most. Today, Shuman estimated, only 10 to 15 percent of U.S. engineering schools are taking the international experience as seriously as leading institutions. "More needs to be done to provide graduating engineers with the ability to become world citizens, to better consider the long-term ramifications of their decisions, and to address global issues such as sustainability," he observed. What's at stake is making U.S. graduating engineers more attractive to prospective employees and demonstrating that these students are willing and able to work cross-culturally and to take overseas assignments. The challenge of accomplishing these goals, according to Lohman, is to figure out how to integrate international programs into the engineering curriculum, to assess and define what global competency is, and to examine a school's international program to ensure those defined competencies are being instilled in students. "This will require scholarly approaches that analyze students' global experiences and ensure that they are achieving the desired results," he explained.

Programs and Consortia to Promote Internationalization

As students' needs for international educational experiences grow, engineering schools are offering more programs aimed at fulfilling them. For example, Virginia Tech's senior year abroad program allows students at one university to complete the senior year of their bachelor of science (B.S.) degree by attending courses at the other university and still graduate on time. Students from the Technische Universität Darmstadt (TUD) can complete their senior year at Virginia Tech studying mechanical engineering and vice versa. Plans are also in the works for the Dual Bachelor of Science in Mechanical Engineering degree consortium between Virginia Tech, TUD, and KTH in Sweden. Students will spend summers at one university abroad learning conversational language skills and their entire senior year at the other where they will learn operational language skills and earn a second B.S. in mechanical engineering. "Our goal is to educate engineers to bridge the U.S. and German engineering economies," said Bøhn. The Plus 3 program at the University of Pittsburgh is designed to interest a relatively large portion of first-year students in international study. The three-credit course includes a two-week trip abroad with U.S. students

working in teams with local students, hear guest lectures, and make several cultural visits while in the host country. The school is also a cosponsor of the International Technology, Innovation and Leadership Conference (INNOVATE), created by the International Association of the Exchange of Students for Technical Experience (IAESTE) and Rice University in 2004, which allows undergraduate and graduate technical students to examine the relationship between technology, globalization, and leadership in the contemporary marketplace. Student delegates spend five days each in two locations in Asia participating in meetings with key business, academic, and government leaders and also conduct professional site visits to companies.

Erin Carmichael, who will graduate from the University of Pittsburgh in 2008 with a B.S. in chemical engineering, attended the conference in 2007 with 40 American and 20 international students from Singapore, Japan, China, and India. "We visited various companies in Bangalore and Beijing and participated in panel discussions with entrepreneurs about education, business, overseas industries, and engineering projects," she said. Before the conference, Carmichael had envisioned herself being able to work in Europe or South America, but not Asia. "The exposure I got to students and people from other countries demonstrated that I could understand other cultures and other peoples' goals and plans. It shrank the world for me," she explained. The university takes the internationalization of engineering education so seriously that it has recently created an office of the director of international engineering initiatives to address the demands of developing new study abroad, interning abroad, and student exchange programs to generally broaden engineering students' international exposure and integrate international experiences into the curriculum. Beginning in mid-August 2007, Christine Lalley, who has a M.A. in French and will complete her by Ed.D. by the end of 2007, begins the process of working with the leadership of the engineering school to help design opportunities for undergraduate engineering students to have an international experience. "My long-term wish is to offer experiential programs, such as internships abroad and service learning opportunities, to help solve problems in various areas of the world while providing overseas research opportunities for undergraduate students," she said.

Georgia Tech's Innovative International Plan is an intensive degree-long program designed to professionally and personally prepare its

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undergraduates for successful lives within the global community. It allows participants to take a global perspective on their education and integrates internationally related studies, as well as experience abroad, into the participating student's programs of study. For example, in 2005 Michael Schmidt, who will graduate from Georgia Tech at the end of 2007 with a M.S. in mechanical engineering, studied thermodynamics, machine design, and production automation systems for one semester at the Technical University of Munich and then interned at Siemens in Germany for five months working with fuel cells and battery and energy storage technologies. "By becoming immersed in the local culture, I got to see how the German education system is different than in the United States, I gained a broader knowledge of engineering, and many of the companies I've interviewed with appreciate my international experiences," he added.

URI is considered to be one of the leaders in organizing and developing international educational programs and consortia. Its International Engineering Program (IEP) is designed to provide the next generation of engineers with the necessary skills to be effective and successful in the global workplace. Undergraduate IEP students complete their bachelor of arts (B.A.) degree with a major in German, French, or Spanish (and soon Chinese), along with their B.S. in any of the engineering disciplines. Graduate-level IEP students complete a dual degree master's program with a partner university abroad, and postgraduate students will soon be able to complete a joint doctorate in conjunction with the Technische Universität Braunschweig. In addition, URI's National Resource Center on International Engineering Education provides engineering and language educators, international program administrators, deans, provosts, presidents, corporate leaders, and public sector representatives with an opportunity to bolster their efforts to educate American engineers for the global workforce. And the Annual Colloquium on International Engineering Education, now in its 10th year, began at URI. "We began the program because we realized the need for sharing ideas and information about international education and exchange program development. We went through the Fund for the Improvement of Postsecondary Education (FIPSE) for a grant to help get the first meeting off the ground," recalled Grandin. The Colloquium's importance to the drive to continue internationalizing engineering education is evident in increased participation over the last decade.

R. John Ellwood, who will graduate in 2008 with a master's degree in mechanical engineering from URI and the equivalent degree from the Technische Universität Braunschweig, says that his international education experience will make him more competitive and flexible after graduation. "Being exposed to different cultures has changed my perspective and demonstrated to me that even a small project requires an ability to communicate with different peoples and work on an international team," he said.

U.S. organizations are also sponsoring consortia and conferences, such as the American Society for Engineering Education, which now has an international division that is making concerted efforts to exchange information about educational opportunities at their annual and regional meetings. IAESTE promotes undergraduate international internship exchanges in 85 countries, and its consortium includes the interchange of education abroad programs among its members. Sponsored by the Institute of International Education, the Global Engineering Education Exchange (Global E3) is an international exchange program for engineering students designed to enable them to earn course credit for courses taken abroad, apply for scholarships, improve language skills, explore internship opportunities, and prepare for a career in the global marketplace. And many schools and universities have either already developed, or are in the process of developing, international education and exchange program opportunities for their students.

European and Asian schools are doing an excellent job of preparing their students to work in international environments, according to Grandin. European students are strongly encouraged, for example, to perform part of their university studies aboard in another European Union (EU) country, in Asia, or in the United States. According to Shuman, German universities and the German Academic Exchange Service (DAAD) have been very aggressive in establishing programs that send their students to either the United States or places such as China, India, Brazil, and Russia. And KTH has an international program in chemical engineering in which the student studies the standard curriculum as well as a language. "The student will spend one year in an overseas country such as China or Japan, study the culture and history, and complete his or her thesis project," Wyss explained.

Europeans have also developed some joint master's degree programs, according to Steinberg. For example, the European Joint Master's Program in advanced material science and engineering between France, Spain, Germany, and Sweden, provides high-level multinational and research-oriented education, along with well-integrated language and cultural experiences. And the European Joint Master's Program in management and engineering of environment and energy between Spain, France, Sweden, Hungary, and the United Kingdom (U.K.), is an interdisciplinary program that prepares students to work in internationally oriented environments in the industrial or academic sectors.

The focus that overseas universities place on exposing their students to international environments means that, for the past 30 years or so, foreign students have come to the United States for their postdoctoral work and the best remained in the U.S. workforce. "Foreign-born engineers are one of the biggest assets the United States has in its efforts to globalize its engineering economy and an important source of exposure to languages and cultural diversity for U.S. students," stated Bøhn.

Corporate Recruiting

Telelogic North America, Inc., in Irvine, California, in conjunction with their parent affiliate, Telelogic, AB, has developed an international internship program for students from both U.S. and overseas universities. The company places its interns throughout its various Centers of Excellence located in places such as Sweden, the U.K., Australia, the Netherlands, China, and the United States. After the application and interview process, the company sends U.S. students overseas for a six-month mentoring and training program, and they then return for an additional three more months of training stateside. Begun in October 2006, the company has already had two Swedish, one British, and one Chinese student complete their internships and return home to work in local Telelogic offices. "We haven't had as much luck finding U.S. candidates," admitted Betty Jo Armstrong, human resources director. So the company will aggressively participate in career recruitment events at schools such as Drexel University, the University of California-Irvine, Carnegie Mellon University, and the University of Texas-Austin. "Our goal is to develop the next generation of Telelogic engineers and to staff our overseas offices with employees trained with the necessary technical, international, and cultural skill sets," she added.

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Nitesh Batra graduated from the University of Maryland in 2006 with a master's degree in computer engineering and is currently a senior business analyst for SyApps, LLC, Herndon, Virginia. While in school, his international experiences demonstrated to him how to respect and value cultural differences and how important it is to resolve differences before deserting a job, company, or career. According to Batra, engineering companies believe that global experiences are valuable because they offer prospective employees a better understanding of overseas markets and the global economy. "Corporations also feel that students who have studied or worked abroad have developed bonds and are better able to understand other cultures," he added.

At URI, global companies work with the school to place students as interns in overseas divisions. "Global corporations are supporting URI's international study abroad programs with grants and financial support, are working with the university to develop an engineering curriculum that integrates international experiences, and participate in the annual Colloquium," observed Grandin. Many corporations also fund studies that examine what can be done to help support universities' international infrastructure and are also increasingly providing internships to students. "These companies need future engineers that understand world markets, others societies, and other cultures," Lohman observed.

Generally, however, Bøhn believes that corporations haven't really started recruiting engineers with a global perspective. "There just hasn't been a reliable supply of engineering graduates with a global perspective to recruit from," he observed. In addition, most companies really haven't examined hiring cross-culturally yet. "However, when Virginia Tech describes its international efforts to recruiters, their response is invariably enthusiastic." A possible reason for any delay in corporations specifically valuing international experiences could be that they are still struggling to define what they mean when they discuss that experience's importance in hiring for a global market, according to Matherly. "There is still a kind of suspicion that studying abroad is some sort of vacation and not an opportunity for students to develop the skills and competencies they say they need," she concluded.

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