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ABSTRACT

This article presents a U.S. and a German perspective on the challenges and strategies of each country in developing globally competent engineering professionals. It reviews U.S., German, and wider EU interests and strategies for attracting international students, as well as national and campus-based programs through which American and German engineering students can study abroad and gain international experience relevant to their future careers. The authors discuss the shared challenges faced by universities in both countries, and the need for further investments by government, industry and academia.

Both the United States and Germany are challenged to graduate and retain enough well-qualified engineers and scientists to meet the needs of their own economies, without relying increasingly on international students and professionals. Each country is addressing this challenge in various ways, based on their higher education systems and the interests of government and the private sector. This article will address one element of the problem and response, the efforts by government and academia to attract and train international talent while also ensuring that its home-grown engineering professionals have the international perspectives that will make them competitive in the global market place. Both of the authors work for national level non-governmental organizations devoted to stimulating international exchange of academics and professionals, working closely with their own governments and the private sector. Neither is an engineer, so our article will focus mostly on how to enhance the "soft skills" increasingly demanded by industry and how to recruit and train a globally effective engineering workforce for the 21st century. We will present initiatives that each country has launched recently, and share some common concerns. Finally, we will offer some conclusions about the likely challenges going forward and how government, academia, and corporations may need to invest in new solutions.

The United States: Maintaining a Leading Role Through Transnational Exchange

With over 4,200 accredited institutions of higher learning and an enrollment of almost 18 million students (including over half a million international students), America's higher education system is one of the largest and most flexible in the world, supported with an enviable mix of public and private funding for research and academic innovation.

However, despite these advantages, U.S. higher education continues to face many challenges, including growing competition for international students, shrinking federal investment in basic research, rising infrastructure costs, and concerns about the employability of today's graduates. To meet these many challenges, U.S. higher education continues to evolve, enabled by new technologies such as distance education, new funding paradigms (including an explosion of for-profit degree granting institutions), and expanded collaboration in teaching and research across disciplines and across borders. All of these will have substantial impact on the education of undergraduate and graduate students in the United States and around the world.

A rapidly evolving international academic environment is also pushing American higher education to compete more vigorously for international talent. In Asia, especially in countries like China, Korea, and India, the expanding higher education sector is already affecting the numbers of their students enrolled not just in the U.S. but also in other major host countries such as the U.K., Australia, and Germany. Many foreign trained graduate students are heading home to build strong graduate programs in their home country universities, which over time may lessen the need to send large numbers abroad for professional training. These developments can be seen as a problem, a success, or a bit of both: they are the logical outcome of America's definition of international students as "non-immigrants" who come here for training and then are required to return home.

International education from the U.S. perspective was aimed at building home country capacity and, as such, is succeeding: Korea and Taiwan are just two examples where huge numbers of U.S.-trained academics have returned to teach or do research at home. With rapidly expanding economies, a growing urban middle class, and increased demand for educated managers, countries like China and India must follow the same educational path as Korea and Taiwan did, sending large numbers abroad to be trained while also expanding their home country higher education capacity to meet the needs of millions more students each year, a need that far outstrips the absorptive capacity of international host campuses.

In Europe, reforms in the higher education system are also affecting America's role in international education. The European Union has vigorously promoted and supported academic mobility within Europe, through which hundreds of thousands of students spend a semester or more in another European country on programs like ERASMUS, SOCRATES, and LEONARDO, in recognition of the fact that their future careers will require the ability to function in several European languages and cultures. This dramatic upsurge in student mobility has stimulated the growth of specialized personnel and infrastructure at European universities to manage student mobility, paralleling the international education professionals and structures on U.S. campuses. European higher education institutions are also developing "American-style" master's degree programs, pushed by the Bologna process and the market, and they are reforming the higher education system in ways that will simplify the transfer of academic credits across borders.

In the U.S., campuses are developing new strategies to serve the educational needs of students who do not travel to the U.S. to study, in addition to continuing to recruit large numbers of international students. Many "host" campuses are developing joint degree programs to be delivered locally at the home country university through a combination of distance learning, visiting faculty, and short-term stays abroad. Such programs provide students with access to international faculty and also encourage joint research collaboration among faculty. However, this model fails to transmit the full benefits of studying outside of one's own culture, with full access to the educational resources of the host university's faculty, libraries, and laboratories. Some higher education researchers raise concerns about whether the quality and level of graduate training and research conducted in these rapidly expanding home country institutions will be sufficient to sustain their high tech development needs.

Challenge to America: Competitiveness in STEM

While the developments cited above respond to the changing needs of national and regional economies, they can also be viewed as a challenge to American higher education's long-held self-perception as the "destination of choice" for internationally mobile students and faculty. The ripple effect on U.S. higher education is increasingly noticeable, especially in key scientific and technical fields where international students are heavily concentrated, and American students significantly under-represented, especially at the graduate level. While STEM (science, technology, engineering, and mathematics) graduate programs in the U.S. are dominated by international students (foreign students made up 47 percent of all graduate enrolments in engineering in the U.S.), other countries are outpacing the U.S. in producing scientists and engineers: of all undergraduate degrees awarded worldwide in science and engineering, 72 percent were awarded outside the United States. Similarly, of all doctoral degrees earned worldwide in science and engineering, 78 percent were earned outside the United States. (*Science and Engineering Indicators 2006*).

There is a growing acknowledgement among American educators and policy makers that scientific research is a global, rather than national, enterprise, and a realization that several countries already surpass America in the production of PhDs in key science/technology fields. This awareness calls for a "revolution" in higher education. These concerns grew along with declines in the number of international students and scholars in U.S. universities: an overall drop of 2.4 percent was reported in *Open Doors 2003-2004*, the annual report by the Institute of International Education (IIE) on international academic mobility, followed by a 1.4 percent drop in 2004-2005, leveling off in 2005-2006. Larger percentage declines were notable in engineering and science fields. The drop was especially pronounced in the field of engineering, where numbers of incoming students from China and India declined sharply at some leading graduate schools. Those numbers have started to rebound, according to *Open Doors 2007* (Bhandari and Chow, 2007) and recent surveys by the Council of Graduate Schools, but the issue has highlighted for key policy makers America's vulnerability in terms of reliance on foreign-born STEM talent and possible shifts occurring as a result of international developments and U.S. responses. In the years following September 11, 2001, business and congressional leaders have joined academics in a proactive call to reform STEM education, strengthen U.S. competencies beginning at the pre-college level, and reduce the perceived dependence on international students and scholars in STEM departments at many U.S. universities.

A number of national studies, including the National Academy of Sciences' *Rising Above the Gathering Storm* and similar reports by the Committee for Economic Development, the National Bureau of Economic Research, and the Council on Competitiveness focus attention on America's growing shortages in STEM graduates, the need to dramatically expand the number of American undergraduate and graduate students in these fields, and the need to improve the teaching of math and science at secondary schools so that the pipeline is increasingly filled with domestic students and less reliant on international graduate students and scholars. These reports also voice growing concerns that current American graduates of such programs lack the cross-cultural skills and international experience required in the global academic community.

The increasing alarm over this issue has been compared to a similarly pivotal event in the 1950s, the Soviet launch of Sputnik, which produced a major U.S. investment in STEM teaching and research. The 1958 passage of the National Defense Education Act provided major new federal funding to strengthen teaching and research in key STEM fields, as well as funding for study of foreign languages and cultures. Rising demand from industry and academia for renewed federal support of STEM teaching and research, expanding America's global competence and competitiveness, may well produce another revolution in secondary and higher education, fueled in part by the realization that we have become overly reliant on international students, and that the competition for globally mobile talent is becoming tighter and less predictable.

To compete more effectively for global talent, the U.S. government and higher education are becoming more actively engaged in dialog and joint action. There is general agreement on the need to streamline the student visa application and review process, to expand student recruitment efforts abroad, and to develop a national strategy for attracting students from outside the United States, countering the post-September 11 misperceptions abroad that international students are no longer welcome. At the same time, U.S. higher education and the federal government are recognizing the urgent need to strengthen the global competence of our own students and faculty members, increasingly at a disadvantage linguistically and in terms of international experience compared to their counterparts in Europe, Asia, and elsewhere.

At the state level, legislators are increasingly calling for reforms in state-funded institutions to ensure that their graduates obtain such skills in the course of their state-supported study. Four states (California, Louisiana, Texas and Nevada) have already passed legislation stressing the importance of international education. Other states are considering similar legislation, which will help state-funded institutions to reallocate resources and make curriculum changes in response to these new laws. An article in *International Educator* (Connell, 2005) summarized key elements of the Nevada Senate's resolution, which contains elements similar to the other states' legislation:

- develop courses of study in as many fields as possible to increase students' understanding of global issues and cultural differences;
- expand foreign language courses;
- provide opportunities for students in all majors to study abroad;
- provide opportunities for domestic and international students to interact effectively and routinely share views, perceptions and experience; and
- develop innovative public educational forums and venues to explore global issues and showcase world cultures.

While there is growing consensus on the broad outlines of what is needed, there is also an awareness that such innovations require time and funding to achieve, and that not all majors can readily accommodate new elements given the constraints of existing course requirements, especially in scientific and technical fields. Calls to bring back a foreign language requirement, for example, meet with strong resistance in science and engineering programs already under heavy pressure to accommodate an ever-expanding body of knowledge in the core curriculum. Attention is increasingly turning to the vehicle of short-term study abroad as a way to infuse American undergraduate education with the global competencies listed above. Such study offers an intense educational opportunity and ideally stimulates longer-term interest in international education, language study, and global careers, while also providing students with skills that will better prepare them to be competitive in the global market place.

Broadening the Definition of Competence to Include Global Competence

There is no consensus on the content or methodology that best develops global competency, and U.S. higher education institutions are undertaking a number of different approaches, but the national dialog has clearly begun. It will evolve very differently than it has in European or Asian universities, since America lacks the kind of national/regional structures which can set higher education policy and mandate reforms. Without a "Ministry of Education" at the federal or state level, America's academic institutions are largely responsible for developing their own academic programs to respond to new challenges, and for doing so within the context of each institution's own educational vision and mission.

Increasingly, institutions have expanded their mission statements to include a commitment to producing "globally competent" graduates who are able to function effectively in the global marketplace and provide leadership in the international arena. The approaches of different types of institutions to implement this vision vary widely and are still evolving. But the direction is clear and is reinforced by a growing commitment to this same goal within various agencies at the federal and state level, and through the professional and regional accrediting agencies.

The issue is especially challenging for engineering schools, where the curriculum is tightly focused on acquiring a set of technical skills and where faculty have traditionally not seen much value in sending students abroad for an international experience. Of the over 200,000 students that study abroad each year, less than 3% are engineering students – a percentage that has stayed fairly flat for the past decade. With the majority of their graduate students (and much of their faculty) foreign-born, many engineering schools find it hard to see the logic in sending their own students abroad for further training, or how that will enhance their students' professional development. Without pressure from employers or government agencies, there has been little incentive to change this approach, although the leadership within the field of engineering is beginning to encourage change through the peer-based accreditation system, as well as through competitive pressure to recruit the best students domestically and internationally.

The voluntary network of quality assurance agencies that review and accredit each academic program and academic institution in the U.S. is led by academics within each field, with only indirect leverage applied by the Department of Education, which can deny support to students attending unaccredited institutions. Many of these accrediting agencies have expanded their assessment criteria to incorporate the notion of "global competence" into the outcomes required for the successful graduate. In some disciplines, including engineering education, this objective is still expressed somewhat tentatively and indirectly, but with a growing acknowledgement that graduates need skills that go beyond mastery of the course content of the traditional curriculum. For example, the Accrediting Bureau for Engineering and Technology programs (ABET) expanded its expectation of skills required in graduates of accredited engineering programs by adding the following "soft skills" in Criterion 3 of the ABET 2000 guidelines:

- Ability to function in multidisciplinary teams
- Ability to communicate effectively
- The education necessary to understand the impact of engineering solutions in a global and societal context
- Knowledge of contemporary issues

An earlier report published by the Institute of International Education (*Towards Transnational Competence*, 1997) presented the conclusions of a joint U.S.-Japan Task Force for Transnational Competence, which spelled out a more general set of core competencies recommended for American and Japanese graduates in any academic field, including:

- Ability to imagine, analyze, and creatively address the potential of local economies/cultures
- Knowledge of commercial/technical/cultural developments in a variety of locales
- Awareness of key leaders and ability to engage such leaders in useful dialog
- Understanding of local customs and negotiating strategies
- Facility in English and at least one other major language, and facility with computers
- Technical skills in business, law, public affairs and/or technology, and awareness of their different nature in different cultural contexts.

The Evolution of Study Abroad as a Mechanism to Develop Global Competence

Decades earlier, the U.S. government had already begun to invest in a global program to achieve these same goals, named after the young Senator who proposed the legislation shortly after World War II. The Fulbright Program, created in 1947 and administered by IIE for the U.S. Department of State, was for many years one of the few vehicles that supported American students and scholars for overseas study and teaching, and also allowed an equal number of international students and scholars to study and teach on U.S. campuses (www.fulbrightonline.org).

Aside from the Fulbright Program and a small number of foundation-funded fellowships for international research, U.S. study abroad was for many decades largely the province of wealthy female undergraduates in arts and humanities fields, who spent a semester or year abroad in Europe to perfect their language skills and visit leading cultural institutions, often accompanied by American faculty members and residing in “foreign student” residences, somewhat isolated from local students and faculty. This picture is starting to change, but slowly. Today, roughly two-thirds of Americans still study in Europe and many fit this general profile, according to IIE’s *Open Doors* data.

Growing concern in the late 1950s about America’s shortage of foreign language and area studies specialists stimulated a new infusion of federal funding (the previously cited National Defense Education Act of 1958) which provided funding for language study in countries or regions where American expertise was lacking. This funding was vital to the creation and expansion of Area Studies across the U.S. higher education scene, and also provided massive funding for scientific research, but did not specifically link these two goals and encourage study or research abroad by science and engineering majors. It was generally assumed that science and engineering majors would not have time in their crowded curricula to pursue language study or to spend a semester abroad, especially if they wished to graduate within the normal four-year timetable. NDEA funding continued for several decades, but at declining levels.

It was not until the end of the Cold War that America again began re-investing in programs to build the global competence of American undergraduates. The National Security Education Program's (NSEP) David L. Boren Scholarships, funded by the Department of Defense and administered by IIE, support approximately 140 undergraduates annually to build language competence and pursue study abroad in “non-traditional” destinations outside of Western Europe and Australia. The most popular language for applicants this year is Arabic, followed by Mandarin, with about 35 percent of Boren Scholars studying in the Middle East/North Africa and another 35 percent studying in East Asia. NSEP's David L. Boren Fellowships provide funds for approximately 85 graduate students to add an international component to their educations, studying languages such as Arabic, Mandarin, and Russian. A third component of NSEP is The Language Flagship, which provides advanced level language training in Arabic, Central Asian Turkic languages, Chinese, Hindi/Urdu, Korean, Persian/Farsi, and Eurasian languages (www.iie.org/nsep).

Another national program funded by the U.S. Department of State and administered by IIE is the Benjamin A. Gilman International Scholarship Program, which provided study abroad support this past year for 777 American undergraduates on financial aid to study anywhere in the world. Both of these programs reach out especially to minority students and students in “non-traditional” majors for study abroad (such as engineering). Engineering majors in the NSEP and Gilman programs make up nearly 5 percent of total awardees, with numbers of applications to the Gilman program from engineers up 81 percent since the inception of the program six years ago (www.iie.org/gilman).

In January 2006, the U.S. president, along with the secretaries of state, education, and defense and the director of national intelligence, announced a series of initiatives designed to increase the teaching and study of the above mentioned lesser-taught languages, including significant increases in opportunities to study these languages abroad. One of these major initiatives is the National Strategic Language Initiative, focused on a dozen or more languages that are not sufficiently studied or taught in the U.S., such as Arabic, Chinese, Russian, Hindi, and Farsi.

By expanding funding for programs like Fulbright, Gilman, and NSEP, as well as exploring support for language teachers and other strategies, the initiative seeks to improve U.S. language skills and expertise in key world areas. While this is not the first time America has tried to make this issue a national priority, the widespread resonance of the issue at the local and campus level suggest that U.S. higher education has finally accepted and embraced the notion that its graduates need to be prepared for global careers and that their educations are not complete without adding international perspectives.

Finally, the newly proposed Lincoln Scholarship Program seeks $50 million in federal funding this coming year (growing to $125 million in future years) to expand the number of Americans studying abroad to one million annually. Based on a call by the late Senator Paul Simon to expand President Lincoln's original vision of "democratizing access to higher education" to include "democratizing access to study abroad," the Lincoln Scholarships would remove financial obstacles and encourage U.S. campuses to expand study abroad participation, especially among students in underrepresented groups (such as minority students, students with disabilities, and students majoring in fields that do not readily accommodate a semester abroad, like engineering and science).

New Models in STEM Exchange

The challenge of "fitting" the study abroad semester into a very tightly sequenced curriculum remains a significant deterrent for engineering majors, as does the labor-intensive work required of home campus faculty seeking to develop exchange programs with international partners. Three unique programs described here aim to address these challenges.

A group of U.S. and European engineering schools formed a consortium in 1995 in order to exchange undergraduate engineering students on a "tuition swap" basis and to pre-certify that the course of study abroad would be accepted for credit toward the engineering degree back home. IIE was asked to administer the U.S. side of this consortium, with a counterpart agency in Paris managing the Western European membership.

Originally called the American-European Engineering Exchange (AE^3), the program received National Science Foundation support to expand the consortium to engineering programs in Asia, Latin America, and Eastern Europe. Renamed the Global Engineering Education Exchange (Global E^3), the consortium now includes over 70 institutions around the world. This past year, over 200 students participated in the two-way exchange, with more than half of them American engineering students studying abroad for a semester or year. Their counterparts come to the U.S. host institutions for non-degree study (6-12 months) or for research opportunities. With support from ABB, Inc.-USA, the program has been especially successful at encouraging female engineering students to study abroad, with women now representing over one-third of Global E^3 students, although they represent only about 20 percent of undergraduates in most U.S. engineering programs.

An NSF-funded evaluation of the program's impact on alumni documented their increased confidence in international settings, their broadened interest in international research collaboration and international careers, as well as increased ability to meet the ABET 2000 Criterion 3 outcomes which related to the "soft skills" required for globally competent engineers. This unique national program continues to attract new member campuses in the U.S. and abroad. It also serves as a resource for campus-based programs, through an online database that lists courses taken abroad by U.S. students and accepted by U.S. engineering programs as equivalent to required courses back home (http://www.iie.org/programs/global-e3).

Member institutions in the consortium have also developed their own bilateral programs with European institutions, including field-specific exchanges and short-term summer study programs through which students can gain international experience, ideally gaining confidence to pursue longer stays abroad later in their career.

In 2005, IIE launched a Central European Summer Research Institute with NSF support, through which U.S. graduate students in science and engineering can pursue research internships in Austria, the Czech Republic, Germany, Hungary, Poland, and Slovakia. An evaluation of the program and its impact on developing global competence among participants is currently in progress.

Private foundations have also recognized the need to create opportunities for science and engineering students to study abroad. For example, the Winston Churchill Foundation's Scholarship Program offers American students of exceptional ability and outstanding achievement the opportunity to pursue graduate studies in engineering, mathematics, or the sciences at Churchill College, the University of Cambridge. For the past 4 years, IIE has worked with the Winston Churchill Foundation to administer the competition to select 12 scholarship recipients who have recently received their bachelor's degrees for awards that will lead to a master's of philosophy (M.Phil.) or certificate from Cambridge after their one-year tenure at Churchill College.

The Whitaker Foundation has also asked IIE to administer their program to support overseas study and research by American biomedical engineering students and scholars. The goal of the program, similar to that of other programs described above, is "to assist in the development of professional leaders who are not only superb engineers and scientists, but who also will lead and serve the profession with an international outlook." (www.whitakeraward.org)

These innovative programs, along with many others developed by individual campuses, are necessary and important steps but are by no means sufficient to produce the large numbers of globally competent professionals needed in the 21st century, not just in science and technology fields but in every discipline. Curricular innovation, international collaborative research, development of dual/joint degree programs across borders, and distance learning will all be needed to provide students with an international perspective and to produce globally competent professionals. Most important, the need has been acknowledged and the challenge accepted by academics and university officials who are now actively engaged in efforts to expand the international character of their programs and graduates. With growing calls for support from federal and private sources, and a recognition that America's global competitiveness depends on globally competent graduates, campus leaders across the U.S. are accepting the challenge to internationalize their institutions.

Germany: Capitalizing On the Moving Force of Europe

Engineering has traditionally occupied a prominent place in German higher education and society. While only about 5 percent of U.S. baccalaureate degrees are awarded to engineering majors, 18 percent of graduates in Germany earn their degree in an engineering discipline.

Still, that is down from nearly a quarter in the '90s, when the popularity of engineering with high school graduates heading for university declined sharply. From 1991 to 1997, the number of first year engineering students dropped 20 percent. The decrease was initially caused by a temporary fall in job opportunities for recent graduates, but continued for several years after the job market had fully recovered. In fact, due to the shortage of engineering graduates, the Schröder government launched a kind of German "green card" for the first time in the late '90s, in order to attract more foreign engineers and computer specialists to Germany. Since the beginning of the new millennium the number of first-year students has risen and is now at an all-time record level of more than 85,000.

German higher education has two separate branches, research universities (including some "Technical Universities" like Munich or Aachen that started as engineering schools but now offer a wide range of fields) and the more recent *Fachhochschulen* (universities of applied sciences) providing more practical-oriented programs at bachelor's and master's level. *Fachhochschulen* account for nearly two-thirds of all engineering degrees offered in Germany.

Reshaping the curriculum: the Bologna process

As in most of continental Europe, higher education in Germany is currently undergoing a thorough reform connected to the Bologna process, which has the ambitious aim of creating a European Higher Education Area with compatible and comparable degrees by the year 2010. The most salient feature of the process is the substitution of traditional national degrees with a three-tier system of bachelor's, master's, and doctoral degrees. In the past, students in German research universities earned their first degree (called *Diplom*) after at least five years of study. In academic terms, the traditional *Diplom* degree is comparable to a North American's degree.

Fachhochschulen offered shorter programs of normally four year duration (including two "practical semesters" spent with internships and project work in companies) leading to a *Diplom* (FH) degree, in this case roughly at bachelor honors level.

In the future, both types of institutions will offer bachelor's and master's programs, though the institutions will keep and develop their distinguishing profiles, with universities preparing for more research-oriented careers and *Fachhochschulen* being more application-oriented.

The transition to the new degree structure requires a profound revision of existing curricula if the new bachelor's degrees are to enable graduates to function in employment. Though this curricular reform requires a lot of energy of both faculty and administrators, it also provides a unique opportunity to reshape educational programs and think out of the box.

The purpose of the reform is twofold:

Domestically, the introduction of bachelor's degrees at research universities would shorten the time needed to earn a first degree. In addition, more structured programs should increase the percentage of students completing programs within their standard duration and diminish dropout. At present, engineering students, for example, on average take nearly 16 months longer than the standard duration of the program to complete their degrees. The number of graduates earning a *Diplom* degree in engineering is currently only about 60 per cent of the number enrolling as first year students five or six years earlier.

Internationally, the more compatible degree structures will help to attract more graduate students from other countries in Europe and beyond and enhance outbound mobility of German graduates seeking a graduate program elsewhere.

While some other European countries have introduced the new degree structure for all of their students at once, Germany has opted for a more gradual transition, during which traditional and new programs are offered in parallel. So far, only a minority of students is enrolled in bachelor's programs. But about half of first year students are now enrolled in bachelor's programs and universities expect to complete the transition in the next four to five years.

It is therefore somewhat early to predict whether and how the new degree structure will change current patterns of international mobility of engineering students. Presumably, both incoming and outgoing mobility for master's programs will increase significantly. On the other hand, many German students might find it more difficult to squeeze a semester or year abroad into shorter and more structured undergraduate programs. Some educators have even voiced concerns that the creation of a "European Higher Education Area" may eventually lead to less rather than more outgoing international mobility. These challenges and concerns would probably be addressed most effectively if institutions entered into even more agreements with partner institutions abroad on organized student mobility, thus pursuing a trend that had already begun in in the early '80s.

Attracting more international students to Germany

The introduction of more internationally compatible degree programs has contributed to the phenomenal increase of the number of international students studying in Germany in recent years. In just five years, from 1999 to 2004, the total number of foreign students in Germany increased 50% to 246,000 (numbers have been stable since then). Virtually all of the increase is due to non-resident international students, while the number of immigrant students with foreign passports who have already attended high school in Germany has been stagnant at the low level of some 60,000.

Germany is, along with France, the third most common destination worldwide for international students, second only to the U.S. and Britain. Not surprisingly, given the good reputation of engineering education in Germany (and of German technology), many international students seek degrees in these fields. More than 50,000 foreign students are enrolled in engineering programs, comprising 21 percent of the total international student population. Overall, the most important sending countries, not counting resident aliens, are China, Bulgaria, Poland, Russia, Morocco, and Turkey. As recently as a decade ago, India sent only very few students to Germany. Now, India is second to China only in the number of international PhD recipients in Germany (first in chemistry and biology and second in mechanical engineering).

Though German post-war governments have always been more supportive of international student mobility, both incoming and outgoing, than most other countries, the internationalization of higher education has ranked very high on a non-partisan political agenda since the late '90s. Policy makers feared that Germany might lag behind some competitors, in particular the U.S., in attracting students from the emerging countries in Asia and Latin America. The international attractiveness of German higher education is now also widely seen as a benchmark of its quality and of the services it provides to domestic students and to society at large.

In a big program of "investments into the future" launched by the German federal government in 2000, internationalization and international marketing of German universities ranked alongside high tech communication and transportation infrastructure in importance. The German Academic Exchange Service (DAAD), the national agency for international higher education cooperation and the largest organization of its kind worldwide, got a budget increase of more than € 20 million from this program.

DAAD was thus able to launch a huge international campaign to better market German higher education and help individual institutions implement their own internationalization strategies, including start-up funding for the first "off shore" campuses or departments of German universities in places like Cairo, Singapore, or Bangkok. Much of the German effort in transnational education is in engineering, as potential students and international partner institutions and governments perceive German universities to be particularly strong in this field. Engineering accounts for nearly half of the 74 German off-shore programs currently supported by DAAD.

Mobilizing engineering students: the surge in study abroad

While engineering programs in Germany have always attracted a sizeable number of international students, outgoing international mobility was weak until the '80s. This has now changed.

Overall, the percentage of German university graduates who have studied at an international university for at least a semester is now around 16 percent (and even higher in research universities). The leading destinations are the France, the UK, Spain, and the U.S., each with a share between 10 and 15 percent. An additional sixth of the student body spends time abroad for other education-related activities such as language courses or internships, and the U.S. is the most popular destination.

These percentages have more than doubled since 1991. But the increase in engineering has been even more spectacular. Less than 2 percent of students in these disciplines studied abroad in the early '90s. That number is now up to more than 10 percent. Participation rates of engineering students at research universities are now close to the overall average, while *Fachhochschule* students still lag somewhat behind, as their fellow students do in all fields of study.

Two main reasons explain this surge of outbound student mobility:

First, students and employers are more aware that graduates will need to function in global working environments for much of their career. On a résumé, study abroad is now nearly as indispensable as good computer skills or proficiency in English.

Second, the European Union has supported study abroad for hundreds of thousands of students through its ERASMUS program. The program was launched in 1987 to enhance student mobility within Europe, and a 10 percent international mobility goal was set for European students. As ERASMUS is based on inter-institutional arrangements on programs and credit, it has also led to much more open and generous attitudes of faculty when it comes to the recognition of courses taken abroad, even if they may be slightly different in content or structure from those offered at the home institution. Participating students receive some, though mostly rather small, financial support from the EU (€ 100 or so per month). More than 150,000 European students now participate in ERASMUS each year, including 24,000 Germans.

For many years, DAAD has run a similar program (ISAP) to support the exchange of small groups of students between departments in Germany and their counterparts outside Europe. While DAAD funds the German students (much more generously than under ERASMUS) and some faculty exchange, partners contribute tuition waivers and fund their own students going to Germany. Exchanges with North American institutions account for about 70 percent of this program that sends nearly 1,000 German students overseas each year, more than 200 of them in engineering.

Some institutions have even gone a step further and developed joint degree programs, where students study at a German and an international institution and are awarded both degrees, thus enabling them to compete for positions on at least two national labor markets at par with domestic applicants. The longest-running programs of this type were already launched in the '80s, most in engineering or business administration, with a very strong participation of *Fachhochschulen* on the German side. French and German institutions have developed the greatest number of such joint degree programs thanks to strong political and financial support by both governments since 1988. Twenty-two percent of the students enrolled in one of the 142 programs now being offered under the umbrella of the "Franco-German University" are in engineering. Transatlantic degree programs are also in the focus of the new "Atlantis" program jointly run by the European Union and the U.S. Department of Education. Fifteen such programs have been selected under the first two competitions in 2006 and 2007, five in engineering, of which two with German partners.

Developing study in Germany for American engineering students

Leading U.S. engineering schools are developing comprehensive strategies to include a global component into their programs and encourage their students to have an international experience, as discussed in the section of this article devoted to U.S. perspectives. Europe should figure prominently in such strategies as much of America's economic and technological cooperation is with its transatlantic partners. For example, more than a third of total U.S. direct investment in 2004 was in the European Union, and Germany attracted twice as much American investment as China.

Organizations such as DAAD are reaching out more actively to scientists and engineers, trying to pave the way for more reciprocal mobility and to overcome obstacles like the language barrier and credit issues with innovative programs, as highlighted below.

As early as 1987, the University of Rhode Island (URI) started its International Engineering Program (IEP) where students major in both engineering and a foreign language and spend a semester or even a year abroad with an internship in industry and/or regular enrollment at a partner university. Due to the additional content and qualifications, the program takes five years to complete instead of the usual four. The oldest and largest component of the program is the German one, the Technical University of Braunschweig being URI's partner institution. IEP has now been expanded to French, Spanish and Chinese. Currently, a total of 200 students are enrolled in the program, and over 150 students have completed six month internships in Germany alone. URI and the Technical University Braunschweig are now developing a dual degree program at the master's level, with support from the National Science Foundation.

Earlier in this decade, DAAD invited groups of North American engineering deans to tour Germany to learn more about engineering education there and to establish contacts with German colleagues. For three years now, DAAD has organized German-American workshops in conjunction with the annual conferences of the American Society for Engineering Education (ASEE). The 2006 workshop in Chicago was dedicated to transatlantic degree programs.

One immediate result of these and other efforts has been a considerable increase in the number of science and engineering applications to scholarship programs to Germany for North American undergraduates and graduates. The share of science and engineering students in DAAD's flagship graduate scholarship program has doubled since 2001 and now makes up close to a quarter of the program. Typically, these graduate students do experiments for their doctoral research in German labs, often based on existing contacts of their American advisors. However, the percentage of engineering applicants and awardees is only around 5 percent, far from satisfactory given the good quality and reputation of engineering research in Germany.

Since 2005, 17 German universities received DAAD start-up funding to develop content based summer programs developed jointly with leading American universities to serve the specific needs of American undergraduates. Nine of the new programs are engineering. These programs focus on fields like process engineering, automotive engineering, and renewable energy. American partner institutions include the University of Michigan, the University of Wisconsin, and California Polytechnic State University.

A success story: RISE

However, the most exciting and attractive program by far has proven to be RISE (Research Internships in Science and Engineering), which was first launched two years ago. RISE is for American undergraduates to work with German doctoral students in their labs for 6 to 12 weeks during the summer. The students make real contributions to their research field while experiencing full immersion into a foreign culture. RISE interns do not need to be, and mostly are not, proficient in German, as the working language in the host labs is English.

This summer, close to 500 different projects in universities and research institutes (like Max Planck, Fraunhofer, Helmholtz) are interested. American and Canadian students register in a database in December/January and apply directly to potential hosts for projects in which they are interested. 846 students filed a full paper application after initial online contacts with a host. DAAD was able to support 298 students with a cost-of-living scholarship, health insurance, and work permits, triple the number originally budgeted for, thanks to additional support from universities, research institutions, private industry, and professional associations.

The RISE projects are not trivial and the interns are generally involved with serious research, focusing on specialized topics and state-of-the-art methods and equipment. This makes the program attractive for students who are genuinely interested in research and eager to get hands-on experience. It is hardly surprising that many applicants are first-rate students, often from excellent institutions. In fact, the grade point cut-off for a scholarship in this program in 2006 was a near-perfect 3.8.

Based on a survey of former RISE participants, the IEE evaluated the program in early 2006. At the same time, applicants registering for the 2006 round were also surveyed about their motivations for wanting to participate in the program. Interestingly, in the latter group research experience ("ability to engage in practical, hands-on research") ranked nearly as high as the international dimension of the program ("desire to work/travel abroad"), both with around 60 percent of respondents registering these reasons among their "most important" motivations.

Sixty percent of actual participants had never been to Germany before and only 43 percent had learned German before their RISE experience. The program does, therefore, seem to attract considerable interest with students who would not otherwise have thought about studying in Germany, and perhaps not even in any foreign country. All the more interesting is the fact that 92 percent of returnees are considering working or studying in Germany again.

This reflects a high degree of satisfaction. Ninety-seven percent of the undergraduates and 86 percent of the German hosts were satisfied overall with their RISE experience, and most would recommend it to their peers.

German graduate students had been a largely untapped resource for international education so far. Besides getting some help in carrying out their own research (in fact, the net benefit in terms of time saved was limited for most hosts if time spent on supervision is subtracted), most hosts said they improved their English language skills and their capability to function in a multicultural environment, both important advantages for their further careers.

And although easy communication in English is no doubt critical for the success of this program, many participants have felt encouraged to learn German by their positive experience in Germany. Thirty percent of RISE interns have taken language classes after their return to North America. From 2008, DAAD is offering a two week intensive language course in Germany before the internship for RISE participants with no or little German.

Since 2007, the DAAD has launched a parallel program, called *RISE professional* for internships in companies of graduates, graduate students and undergraduate DAAD alumni. Some 150 internships are on offer for the summer of 2008, and DAAD hopes to support 100 interns.

Conclusions: a Challenge for Higher Education

Engineers need global competencies and multi-cultural skills as much as any other professionals. Still, there is less of a tradition in this field to acquire such skills through study abroad than in many other fields. The academic benefit of study at a foreign university is less immediately obvious in engineering than, say, in languages or history. Engineering professors tend to be more reluctant than others to grant credit for studies conducted with international colleagues. And the students themselves typically are not fluent in foreign languages.

Still, both European and, more recently, American experience shows these obstacles can be overcome through innovative programming. The international mobility of German (and other European) engineering students has increased dramatically over the last 15 years. This is to a great extent due to exchange programs involving faculty on the departmental level. Through specific agreements on courses and credits, they better understood each other's educational principles and developed trust in the quality of their partners' teaching, the indispensable basis for more flexible and generous approach to curricular differences.

Similar attitudes should develop as more American universities develop exchange agreements with European partners, which will be made easier with the convergence of degree structures on both sides of the Atlantic.

There are also interesting new models for how engineering students can get access to meaningful international experience in which barriers like language and credit are circumvented or at least lowered. Opportunities for research experience, internships, and summer programs taught in English may encourage more American engineering students to make that most difficult first step – and perhaps come back later for longer and more ambitious projects.

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