# AC 2007-854: EDUCATING ENGINEERS FOR THE GLOBAL WORKPLACE

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# EDUCATING ENGINEERS FOR THE GLOBAL WORKPLACE

Abstract

Our paper will give a brief report on the study “In Search of Global Engineering Excellence: Educating the Next Generation of Engineers for the Global Workplace” that eight international universities undertook between November 2005 and November 2006.
The research team focused on the main areas:
*Engineering in a Global Context*. Team members first considered the historical, social, and economic context of engineering in their countries, and the trends and challenges with respect to their engineering workforce. They also studied the skills and abilities industry expects from engineers—now and in the future—and considered whether the emerging engineering workforce is well prepared.
*Preparing Global Engineers.* The team then reviewed the various educational approaches used to prepare engineers for global practice, including an examination of their own engineering programs and universities. They considered all levels, undergraduate, graduate, and continuing education, as well as organizational and faculty development.
*Recommendations.* Finally, based on their observations of the state of the global engineering workforce and engineering education programs, they identified four critical challenges to better prepare engineering graduates for global practice.

**I.**

Our paper will give a brief report on the study“In Search of Global Engineering Excellence: Educating the Next Generation of Engineers for the Global Workplace” that eight international universities undertook between November 2005 and November 2006. The results were first presented at a press conference in Frankfurt, Germany on November 10, 2006. We would be delighted to give you a copy of the entire study at the end of our session.

Globalization is radically changing the way national economies around the world design, produce, distribute, and consume goods and services. Engineers are in the midst of this dynamic development. They use their knowledge of foreign cultures in designing products and services for global markets. They often work in teams on projects with members from different continents and cultures. They must be internationally mobile, whether physically or virtually.

These requirements raise critical questions: Is tomorrow's engineering workforce—whether in Africa, Asia, Europe, North or South America—being well prepared to meet the demands of the global economy? What new skills are required to be not only a "good engineer" but also a “global engineer”? How do we instill these skills? Will globalization lead to an increasing employability and status gap between “global” engineers who comfortably maneuver in an international environment and "local" engineers who do not?

To respond to those question in particular and to the growing international concern about the preparation of the engineering workforce of the future in general, the German automotive supplier Continental generously supported the study “In Search of Global Engineering Excellence: Educating the Next Generation of Engineers for the Global Workplace.” Its participants came from universities known for their expertise in engineering education around the world: ETH Zurich , Georgia Institute of Technology, Massachusetts Institute of Technology, Shanghai Jiao Tong University (China), Technische Universität Darmstadt, Tsinghua University, Universidade de São Paulo, and the University of Tokyo.

II.

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We would like to briefly summarize the key findings of those three areas.

## III. Engineering in a Global Context

The team soon realized that engineering programs within universities are as different as the systems of higher education and the national economies in which they are imbedded. The global situation has a very different look depending on where one stands. In summary, we came to the following brief characteristics of our countries:

• Brazil enjoys the advantage of engineers who are nimble at technology transfer, but the industry needs to increase its technological development capability. We also found that the country needs a more technologically advanced infrastructure and engineers need greater social standing and compensation.

• China's population offers tremendous long-term engineering human resource potential, but the country's near-term industrialization needs and environmental concerns demand attention. While Chinese engineering graduates today could benefit from more innovation and creativity, their strong work ethic and academic skills are highly valued around the world.

• German engineers enjoy high social standing and are known for their innovation, precision, and quality of work. But their lack of mobility and flexibility challenges Germany's ability to maintain an adequate engineering workforce.

• Japan's island geography has produced the world's most resource-efficient, environmentally conscious and flexible engineering workforce, but its customs have also produced "workforce islands" in its industrial community. A strong commitment to one's company fosters a high-degree of teamwork and leverages seasoned engineering know-how, but it also diminishes industrial and educational mobility.

• Switzerland benefits from a long history of multicultural assimilation and international cooperation. While Swiss engineers are known for their strength in science and analytical and problem-solving skills, there is a need to infuse more entrepreneurship and innovation in Swiss engineering education.

• The United States enjoys a robust and technologically advanced economy, but it is increasingly dependent on foreign-born engineering talent. When this is coupled with the growing outsourcing of industrial R&D, American engineering faces a challenging situation.

## IV. Preparing the Global Engineer

Fostering the skills required for global competence will be challenging in an already tight engineering curriculum, engineering programs worldwide have responded to the task of educating students for a global workplace and international networks of knowledge in different ways. The team found a variety of beneficial practices:

• Increasing student mobility to spend time abroad during their undergraduate career. The most common programs involve study, internships, or research experiences abroad. Most are short term (e.g., a summer, one semester) but occasionally may be longer (e.g., a year or multiple stays). Here we found that MIT's International Science and Technology Initiative (MISTI) provides a successful model.

• Internationalizing the educational experience for graduate students through enrollment in foreign institutions. Universities increasingly cooperate by offering dual, double, or joint degree programs. Among most of the participating universities, international doctoral students represent about one-fourth to one-half of the student population in these programs. As models we would like to mention here Shanghai Jiao Tong University's collaboration with the University of Michigan and Tsinghua's Double Degree Program with the RWTH Aachen.

• Stressing language proficiency is a critical skill for a global engineer.

The ability to take full advantage of international opportunities depends on students and faculty members being able to converse in the host country. Thus, most universities emphasize language instruction, partly to assure that students are able to converse at a foreign location and partly to help prepare students for some of the customs and culture of the host country. Increasingly, English is becoming a common language for cross-cultural communication. However, the dominance of English in global communication in engineering, science, and business does not lessen the need for native English speakers to learn other languages. Linguistic ability remains a crucial element of cross-cultural competence.

• Internationalizing the faculty to create sustainable international networks of knowledge.

Internationalizing the faculty can occur in two forms: recruiting international faculty or encouraging local faculty members to obtain foreign degrees and/or participate in international education and research. Faculty members leave and sabbaticals are the most common means of introducing faculty members to international perspectives in education and research. We see ETH Zurich's strategy for international recruitment of faculty members as a model in this area. In the past eight years, 54% of ETH's faculty was recruited outside Switzerland: among them 34% came from Europe and 20% from North America.

• Formulating an overall institutional or organizational framework for globalization.

Internationalizing the university and engineering education is a resource-intensive endeavor that demands imaginative approaches to curricular structuring, teaching methods, international partnerships, and administrative support. International efforts and processes are increasingly embedded in wider institutional developments ranging from new structures for interdisciplinary

education and research to the formation of centers of excellence to the establishment of an institutional presence in other parts of the globe. A prime example for such a strategy is Georgia Tech's ambitious International Plan. The hallmark is this program is the integration of international studies and language learning into the student's disciplinary studies. The program was launched in the fall of 2005 with a 3 million USD commitment from the president of Georgia Tech. The goal is to enroll 300 students per year by the year 2010. The International Plan is part of Georgia Tech's strategic plan to have 50% of its baccalaureate students graduate with international experience.

• Integrating experience-based programs at all levels into an international context. These programs often result from the need for engineering programs to provide students with more real-world hands-on educational experiences and for faculty members to update their skills and maintain their connections to current industrial challenges. These experiences may be in the form of international student competitions, design projects, research experiences, or internships. The Technische Universität Darmstadt, for example, regularly involves its students in international design competitions and hands-on projects.

## V. Recommendations

The ability to live and work in a global community is —today — an important requirement for engineering graduates. They need to have broad engineering skills and know-how, be flexible and mobile, and be able to work internationally.

Providing these competencies will require the collaborative actions of industry, government, academia, and engineering-related agencies and organizations to address four critical challenges. The research team of the "Global Engineering Excellence Study", therefore, issued the following four recommendations:

**1. Global competence needs to become a key qualification of engineering graduates.**

Global preparation must move beyond "add-on" programs; knowledge of the fundamentals and dynamics of globalization as well as opportunities to be immersed in study, work, or research abroad are key elements that should be integrated into engineering programs. Universities should make international preparation a priority in their institution's strategic plans and actively pursue it. Universities need to recognize the positive correlation between the degree of international academic and research collaboration and the quality of the institution and its goals to provide a world-class education. International research and education should finally come together, and research universities are uniquely positioned to exploit this international potential.

The study team also felt, that industries should play a greater supportive role. They should use their influence and capacities on university advisory boards to promote global preparation. More opportunities for students to be involved in global teams, projects, and designs are needed from industry, either through on-campus experiences, such as research and educational projects or case studies, or off-campus internships.

**2. Transnational mobility for engineering students, researchers, and professionals needs to become a priority.**

This means concretely, that barriers to studying, working, conducting research, and attending meetings internationally need to be removed and incentives expanded. To achieve this,

universities and engineering programs need to develop more flexible approaches to their educational programs. The team members found that strong inter-institutional international partnerships involving student exchanges, dual, double, and joint degrees, and transfer credits are proven means to enhance student participation. Universities should also encourage and provide more support for inter- national faculty member leaves and sabbaticals.

Funding agencies should provide more support for programs that enhance international study, work, and research programs. Accreditation agencies and licensing boards need to continue to work toward the mutual recognition of accredited degrees and licensure. And finally, industry can support faculty members and student mobility by providing greater financial support, employment opportunities, and of course research projects. In particular, industry leaves and sabbaticals would both promote awareness of the global practice of engineering and provide invaluable international exposure.

**3. Global engineering excellence depends critically on a mutual commitment to partnerships, especially those that link engineering education to professional practice.**

The team recommends that industry must take the lead in developing opportunities for students to practice engineering in a global context, whether through on-site employment, virtual involvement in global engineering projects, or other experiential opportunities. Universities should initiate more collaborative activities with industry, such as research, educational projects, and transnational internship programs. Significant industry representation on advisory boards and invitations of industry engineers, managers, and researchers to campus regularly will promote mutual understanding of university-industry needs and perspectives on global engineering. In addition, professional engineering organizations should collaborate more across the borders; they should work to strengthen the dialogue between professional practice and academia; they should help define and monitor global engineering qualifications.

**4. Our final recommendation is that research on engineering in a global context is urgently needed.**

The phenomenon of global engineering is still emerging. There is a need for a theoretical foundation on learning behavior and models as well as on organizational processes and management methods focused on instilling global competence in engineers. Government agencies need to create programs that support research on global engineering processes, methods, and tools as well as on understanding learning behaviors. Industry participation in the assessment and evaluation of international experiences is vital. Without the real-world assessment of the skills, capabilities, and abilities of engineering graduates, achievement of program objectives will remain unknown.