What Is Global Engineering Education For?

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The biggest challenge of globalization

"Is it desirable and is it possible for us to eventually have what we might call a 'world degree' in engineering?" So asked the session moderator at a recent meeting of the European Association for Engineering Education. Apart from the Danish student whose engineering optimism prevented her from ruling anything out as impossible, the panelists from Belgium, Germany, Ireland, Spain, Sweden, and United Kingdom forcefully agreed that achieving such uniformity was neither desirable nor possible. They clearly could not imagine replacing their own practices in engineering education with those that appeared dominant in another country.

The question was important. It indicates the growing commitment among engineering educators across the planet to produce "global engineers." In 2006, educators representing eight elite institutions (Escola Politécnica da Universidade de São Paulo, ETH Zürich, Georgia Institute of Technology, Massachusetts Institute of Technology, Shanghai Jiao Tong University, Technische Universität Darmstadt, Tsinghua University, and University of Tokyo) asserted that "[t]he ability to live and work in a global community" is an important requirement for engineering students today. In addition to having "broad engineering skills," they need to be "flexible and mobile, and able to work internationally."[1] Like most other calls for "global engineering skills," these engineers focused on preparing engineers to serve global markets.

I maintain that the biggest challenge that globalization poses to engineering educators is somewhat different. It is to do a better job of helping students understand who they are, why they learn what they learn, and what their broader commitments are as engineers.

A study of international educators

I recently directed a study of sixteen engineering educators in the United States who have made risky career commitments to provide international and global engineering education for their students.[2] The contributors include nine engineers, five non-engineers, and two hybrids (including myself). All wrote detailed accounts of career trajectories that led them to international and global engineering edu-

1) Anderl, Reiner, Gong, Ke, Cai Li, Nian, Kaminski, Paulo, Netto, Marcio, Kimura, Fumihiko, Lohmann, Jack R., Plattner, Bernhard and Widdig, Bernd. 2006. In Search of Global Engineering Excellence: Educating the Next Generation of Engineers for the Global Workplace (Hanover, Germany: Continental AG), 1.

2) Downey, Gary Lee and Beddoes, Kacey, eds. 2010 What Is Global Engineering Education For?: The Making of International Educators (San Rafael, CA: Morgan & Claypool Publishers) (forthcoming October).

cation. A key feature of their pathways has been experiences outside home countries that led them to question their own knowledge and broader social commitments. These experiences led them to want students to have similar opportunities, to help them both as people and as engineers.

Daniel Hirleman (Purdue University) explains how working as a graduate student in Denmark led him to become more reflective about his career assumptions and commitments. "I was the minority culture," he reports, "and was forced to look at American culture from the outside." Having to define and defend himself led him to expand his understanding of engineering service beyond private industry while building a successful career in mechanical engineering.

Linda Phillips (Michigan Tech/University of South Florida) describes a pathway that took her from a first career as a construction executive to a second as a university lecturer teaching international senior design. Challenging students to work on jobsites in Bolivia, she found they "quickly appreciate and respect the construction workers' strength and stamina as well as their wisdom." She now helps students learn to question what sorts of construction projects engineers design and build and why.

Joseph Mook (State University of New York at Buffalo) found the importance of working at the University of Hanover to be "less about math than . . . about myth." His experiences in Germany led him to question the images "I thought I knew about myself and the world I lived in." After achieving tenure in mechanical and aerospace engineering, he turned to international education as an academic specialty. His goal is to help students achieve "real, life-changing, inner transformation" in ways that make them question who they are and what they are doing as engineers.

What are engineers for now?

Engineers have long been built to serve countries. I survey their contrasting commitments in an elective course for engineers called Engineering Cultures.[3] It shows how what it means to be an engineer, what engineers have valued as their knowledge, and what they have emphasized as their broader social commitments have varied dramatically across time and from place to place.

It matters, for example, that where elite French engineers have tended to place highest value on mathematical theory and aspire to work in government where they have constituted the highest-ranked occupation in the country, British engineers have continued to place high value on forms of practical knowledge and to work in the private sector where, to this day, they constitute a relatively low-ranked occupation. It matters that German engineers attained the status of highly-valued workers only after German unification in 1871 and then later become model German citizens at two distinct levels through their commitment to precise, high-quality technics. It matters that U.S. engineers developed an unusual commitment to balancing practical and theoretical knowledge while pursuing progress as low-cost production for mass use.[4] It matters that the Kwa-hak-ki-sul-ja (scientist-engineer) rose to prominence across Korea only after the end of Japanese colonialism and rapid technological and economic expansion under President Park Chung-hee.[5]

The internationalization of engineering work is making

3) For free access to my twenty-six video lectures on engineers across Britain, France, Germany, Japan, Soviet Union/Russia, and USA, see http://globalhub.org/resources/11. See also Downey, Gary Lee. 2008. "The Engineering Cultures Syllabus as Formation Narrative: Critical Participation in Engineering Education through Problem Definition," St. Thomas Law Journal (special symposium issue on professional identity in law, medicine, and engineering) 5/2: 101-30; Downey, Gary Lee, Lucena, Juan C., Moskal, Barbara M., Bigley, Thomas, Hays, Chris, Jesiek, Brent K., Kelly, Liam, Lehr, Jane L., Miller, Jonson, Nichols-Belo, Amy, Ruff, Sharon and Parkhurst, Rosamond. 2006. "The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently," Journal of Engineering Education 95/2 (April): 101-22.

4) Downey, Gary Lee. 2007. "Low Cost, Mass Use: American Engineers and the Metrics of Progress," History and Technology 22/3 (September): 289-308.

5) Han, Kyonghee. 2010. "A Crisis of Identity: The Kwa-hak-ki-sul-ja (Scientist-Engineer) in Contemporary Korea," Engineering Studies 2/2 (forthcoming August).

it clear that the "global" is not one new arena but many. Engineers certainly need to learn much more about engineers and non-engineers across the planet. Study, internships, and service learning in other countries can be helpful and important, as can elective courses such as mine.

But the big news and challenge of globalization for engineering education is the importance of questioning and studying one's own identity as an engineer, including the knowledge one values and the broader social commitments one takes for granted in doing engineering work. The work of building such questions into engineering education is the responsibility of all engineering educators and the entire curriculum, including the most technical of technical courses and instructors. The big hurdle to overcome is to move these questions from the periphery of engineering curricula to their core.[6)]

Engineering science courses tend to focus on making sure students demonstrate an ability to implement their practices. Rarely do they challenge students to articulate the value of those practices or explain how they might be distinct from other practices. Has a thermodynamics course in mechanical engineering ever helped students understand how it differs from a thermodynamics course taught in chemical engineering? It is important to begin asking students such questions as: What are the key entities and processes in this thermodynamics course and how do they relate to one other? How are these entities and processes similar to or different from those in the heat transfer course students take? How do thermodynamics and heat transfer connect to one another, or not? What objects does one see and practices does one gain by invoking first-law or second-law equations? It is in beginning to ask such questions as these that practices of critical self-analysis that the international educators developed on their own move to the heart of engineering pedagogy and from there to everyday engineering practice.

Beyond the individual courses, another step might be to recast the current core as a single track in a degree program that includes other, new tracks. The existing core becomes the "engineering science" track, structured perhaps especially to prepare students for research positions or graduate school. In like fashion, an "engineering design" track could include coursework in industrial design, architecture, or other design disciplines, preparing students for careers emphasizing design work. An "engineering and management" track would specifically help students prepare for the work of collaborative problem definition in private industry, especially by training them to analyze the types of knowledge other non-engineering managers possess and use. An "engineering and policy" track or "engineering and society" track would prepare students for the work of collaborative problem definition beyond the firm, e.g., in government or non-profit sectors. A multi-field "general engineering" track, degree, or possibly advanced degree program could prepare students to function effectively as mediators among different types of engineering specialists.

The bottom line: the contemporary challenge to produce global engineers is not about how to cram more skills into the minds and bodies of engineers in the same amount of time. It is to make engineers better problem definers and problem solvers by integrating into engineering routines questions about what engineers are for and what engineering is for in the first place.

6) For elaboration of what follows, see Downey, Gary Lee. 2010. "Epilogue: Adding Identities to Engineers," in Gary Lee Downey and Kacey Beddoes, eds., What Is Global Engineering Education For?: The Making of International Educators (San Rafael, CA: Morgan & Claypool Publishers).