National identities in multinational worlds: engineers and 'engineering cultures'

Gary Lee Downey*

Department of Science and Technology in Society,
Virginia Tech, Blacksburg, VA 24061, USA
Fax: 540 231 7013 E-mail: downeyg@vt.edu
*Corresponding author

Juan C. Lucena

Division of Liberal Arts and International Studies,
Colorado School of Mines, Golden, CO 80401, USA
Fax: 303 384 2129 E-mail: jlucena@mines.edu

Abstract: An important contemporary change in engineering practice is the increasing internationalisation of work, both through the expansion of multinational organisations and increasing mobility of engineers. International work can break assumed links between working for one's employer, one's country, humanity in general, and oneself. The recent expansion in continuing engineering education (CEE) has generally not included attention to issues in transnational careers. This paper introduces and summarises assessments of 'Engineering Cultures', a liberal arts approach to cross-cultural training for engineers through multimedia modules. These country-based modules examine how what counts as an engineer and engineering knowledge has varied over time and from place to place.

Keywords: globalisation; international work; multinational organisations; engineering practice; cross-cultural education.

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Biographical notes: Gary Lee Downey is Professor of Science and Technology Studies at the Department of Science and Technology in Society, Virginia Tech. He received a BS in Mechanical Engineering in 1974 and BA in Social Relations in 1974 from Lehigh University. He also received a MA in 1977 and a PhD in 1981 in Cultural Anthropology from The University of Chicago. He received the Diggs Teaching Scholar Award for original scholarship in teaching in 1997, the XCaliber Award for high-quality instructional technology in 2003, and the William E. Wine Award for career excellence in teaching in 2004, all at Virginia Tech. He is 2004–2006 Boeing Company Engineering Education Senior Fellow at the US National Academy of Engineering. He is a Member of Cross-Professions Seminar at the Carnegie Foundation for the Advancement of Teaching, and is author of *The Machine in Me: An Anthropologist Sits among Computer Engineers*. He is a Member of the American Society for Engineering Education and the European Society for Engineering Education.

Juan C. Lucena is Associate Professor of Liberal Arts and International Studies Division at Colorado School of Mines. He received a BS in Aeronautical Engineering in 1987, in Mechanical Engineering in 1988, and a MS in Science and Technology Studies in 1990 from Rensselaer Polytechnic Institute. He received a PhD in Science and Technology Studies in 1996 from Virginia Tech. He is 2004–2006 Boeing Company Engineering Education Senior Fellow at the US National Academy of Engineering. He received a NSF CAREER Award, for *Global Engineers: An Ethnography of Globalisation* in the Education, Hiring Practices and Designs of Engineers in Europe, Latin America, and the USA. He is the author of *Defending the Nation: US Policymaking to Create Scientists and Engineers from Sputnik* to the 'War Against Terrorism'.

1 Introduction: a novel challenge to engineering careers?

An important contemporary change in engineering practice is the increasing internationalisation of engineering work. That is, far more than even a decade ago, engineers emerging from educational institutions around the world are finding themselves working in contexts and organisations that include engineers from other countries. The internationalisation of work is, in fact, a key dimension of what is today called 'globalisation'. While often presenting engineers with novel and exciting career opportunities, the prospect of work in international contexts can also be confusing, or even frightening.

Engineering is an occupation that, as historian Ken Alder has shown in a French context, is 'designed to serve' (Alder 1999). That is, engineers expect to bring their knowledge to bear in the solution of problems that extend beyond their own narrowly-defined interests. Indeed, since the emergence of engineering as an occupation in France and Great Britain during the 18th century, the identities of engineers have been linked in important ways to nations and nation states (Downey and Lucena, 2004). That is, engineers have been comfortable in the knowledge that by serving their employers, whether in the public or private sector, they are also contributing both to the welfare of their countries and to human welfare more generally. As individuals, their main challenge has been to recognise what is expected of them in their training and on the job and then perform to the best of their abilities.

The internationalisation of work breaks the links that engineers tend to assume between working for one's employer, working for one's country, working for humanity, and working for oneself and one's family. In other words, pursuing career pathways that take one through international contexts can make it more difficult to determine which ends are served by a particular pathway. For example, if I am a Japanese engineer working for IBM Japan, am I working on behalf of Japan or of IBM's host country, the USA? Or both? Or neither? If I am an American engineer working for Siemens, does that mean I am, in some sense, becoming German? Does becoming proficient in international contexts mean that I have to abandon, or consider less important, my national identity? Do I want international work to be a vehicle for contributing to my country? Is it possible to have a prosperous career personally that also serves both international and national ends?

These questions are relatively new only for engineers from the industrialised countries of Europe, North America, and Asia. For several decades, students and engineers from poorer countries have travelled to the industrialised countries for higher education in engineering, after which they have had to decide whether to stay, return home, or move to yet another location. For example, an Egyptian engineer who received his PhD in electrical engineering from the University of California at Davis reported in an interview (Cairo, 2003) that he never bought a house during his eight-year stay in the USA to remind himself that his plan was to return to Egypt and help his country. Another Egyptian engineer found his decision to return to Egypt especially affirmed when he visited a fellow countryman living an affluent life in Silicon Valley, California. As they discussed their homeland, the man's young daughter happened to enter the room. He began to cry.

These questions of identity can be difficult to answer. The forms such questions take, the extent to which they generate significant tensions, and the answers people give to them all vary from country to country and from engineer to engineer. Some engineers readily embrace international experiences even at the risk of a declining sense of national identity. Others resist the prospect, uncomfortable with the possibility of losing clarity about the guiding objectives of one's career. In both of these extremes, as well across the entire spectrum of possibilities that lie between them, engineers have to make explicit judgements about which ends are most important and which risks to altered identities are acceptable to assume.

One thing that is generally common to all is that engineers generally have to identify and answer these questions largely by themselves. Will continuing engineering education be an appropriate locus for preparing engineers to make such decisions?

2 Background: two pathways for the internationalisation of work

The decline of the Cold War in the 1980s marked a significant change in the dominant world image of relationships among nation states. Since the 1950s, most people had understood transnational relations as a political and military competition between communism and capitalism, with non-aligned states positioning themselves strategically in relation to the two dominant camps. But in the 1980s a new image emerged as international struggle shifted to an economic idiom. The world became a collection of nation states competing with one another in economic terms (Downey 1998; Lucena 2000). This shift has been complicated by a parallel expansion in the size and reach of multinational firms and other multinational organisations.

The US National Science Foundation reported in 2002 that "(t)he globalisation of the S&E labour force is expanding in two ways" (National Science Foundation, 2000). The first way is that the "location of S&E employment is becoming more internationally diverse". For example, since IBM first marketed the System 360 in Europe during the 1950s, the international reach of industrial corporations has expanded to such an extent that they rival nation states in size and economic power. As the *India Times* reported in December 2003, 'Sony is bigger than Pakistan'. That is, corporations constitute over half, or 51, of the largest 100 economic entities in the world today (based on comparing annual corporate revenues with annual national GNPs). Wal-Mart has broken into the top 20, 'well ahead of Sweden' and 'a hair's breadth behind Belgium'.

General Motors is bigger than Saudi Arabia and Turkey, Siemens is bigger than the Philippines, and Toyota is bigger than Portugal (Anderson and Cavanagh, 2000).

Engineers also participate in other sorts of emergent industrial organisations, ranging from R&D laboratories to technological projects carried out by multiple nations, including the reconstruction of war-torn infrastructures. A 1993 Engineering Management Conference held in New Delhi, India, offers an indicator with its title 'Managing projects in a borderless world'. The rebuilding of the transportation infrastructure in Bosnia has included hundreds of civil engineers, especially from NATO countries but from non-NATO countries as well (Arai, 2002; Gaddy, 1998; Popovic et al., 2001; Solomond, 1996).

The second way is that the S&E labour force is expanding is that 'S&E workers are becoming more internationally mobile'. For example, between 1970 and 1989, "Japan sent 730,218 researchers and engineers abroad and accepted 461,445 foreign researchers and engineers" (Nishimoto 1990). In the USA, in 1990 "there were around 234,178 foreign-born engineers representing 12.3% of total engineers", a proportion that by 1995 had increased to 17% (Regets, 1999). Researchers in Australia report that that country experienced a net gain of 27,000 engineers in the period 1987–1999, including a significant proportion from countries in Asia (Birrell et al., 2001).

3 The problem: CEE for transnational careers?

The large-scale shift in thinking and continuing expansion of the industrial sector has driven a comparable expansion of interest in continuing engineering education (CEE) in many countries. In the USA, a major 1980s study of the engineering workforce called attention to continuing education for engineers as 'essential to increasing national productivity' (National Research Council, 1985). A follow-up study identified continued education as a vehicle for increasing the number of engineers in the workforce through 're-tooling' (National Research Council, 1986). ABET 2000 criteria for programme outcomes and assessment states that "engineering programmes must demonstrate that their graduates have a recognition of the need for, and an ability to engage in life-long learning" (ABET, 2002). Other important engineering organisations, such as the National Council of Examiners for Engineering and Surveying (NCEES) and the American Society of Civil Engineers (ASCE), have taken a strong proactive role in encouraging continuing education. CEE even became a significant focus for education researchers (Noyes, 1999; O'Shaughnessy, 1992; Piper, 1990; Schwiebert, 1990). As US-based companies restructure their bureaucracies into more flexible structures of matrix management, they began to expect engineers not to carve a niche in a specific area but to move from project to project, from company to company, and from nation to nation, according to customer and market needs (Smerdon, 1996). Mobility and flexibility emerged as desired characteristics for engineers to have (Lucena, 2003).

Similar interests can be found in other industrial countries. In the UK, the Engineering Council, which regulates the engineering profession through the engineering societies, since 1981, now requires professional development (PD) to engineers who want to be registered as Charter or Incorporated engineers (Evetts, 1998). A similar approach is found in Australia where Engineering Education Australia (EEA), supports a rapidly expanding commitment to professional development. In Japan, CEE can be found within small and medium-sized manufacturing enterprises (Harada, 1991).

Most CEE is designed to support the needs of industry and engineers working in specific projects and with specific needs (Paton, 2002). However, some survey evidence suggests that engineers need CEE that prepares them to be "open-minded to socio-cultural differences" (Eeva-Kaisa, 2000). One educator writing in *IEEE Spectrum* argues that

> "the emergence of multinational corporations with flatter hierarchies has turned such traditionally non-engineering skills as communication and management into prerequisites of functioning effectively in industry."(Geppert, 1995)

According to one personnel director,

> "The ideal employee profile is someone with technical talent who is multilingual, has local customer orientation, plus has flexibility, mobility, and proven competence in multi-markets." (Micossi, 1994)

Another engineering educator maintains that

> "Civil engineering programs at universities and professional development provided by technical societies can contribute to improved multinational consortia by 'internationalizing' their offerings. This step reduces ethnocentrism and promotes a deeper respect for the needs and approaches used by engineers from other cultures." (Ircha, 1999)

A review of programmes and databases for continuing engineering education reveals an ever-growing number of technical offerings but a lack of courses oriented towards cross-cultural education. For example, a survey of US materials at learnon.org (5,000 courses), IEEE, and ASCE identified only two language courses (German, Japanese) at the University of Wisconsin. A search of IEE-approved providers in the UK yielded only three courses with some dimension of cross-cultural training: Human Factors in Industry, and Management of International Business at the University of Warwick, and TQM and Human Resource Management at the University of Exeter. A search of Australian courses yielded only Managing Cultural Diversity to Competitive Advantage and Business Communication Skills and University of New South Wales.

4 'Engineering cultures': an integrated liberal arts approach

In 1995, the authors began developing 'Engineering Cultures', a modular approach to cross-cultural training for engineers that has proven enormously successful at the undergraduate level. The main goal of engineering cultures is to help engineering students learn to work with people who define problems differently than they do. The course travels around the world, examining how what counts as an engineer and engineering knowledge has varied over time and from place to place. Students gradually become 'global engineers' by coming to recognise and value that they live and work in a world of diverse perspectives. Participants gain concrete strategies for understanding the cultural differences they will encounter on the job and for engaging in shared problem solving in the midst of those differences.

Much of the conceptual content involves systematically tracing historical linkages between the emergence of engineers and changing images of the nation state in different countries. Students are typically surprised to learn, for example, that where French engineers have tended to value mathematical theory and aspire to work in government

where they constitute the highest-ranked occupation in the country, British engineers have tended to value craftsmanship and work in the private sector where they constitute a relatively low-ranked occupation. German engineers have exhibited yet another pattern, having attained the status of highly-valued workers only after German unification in 1870 and then later becoming model German citizens through their commitment to precise, high-quality techniques.

Because Britain and France had extensive colonial networks, one can travel around the world today and find countries with unique mixes of influences on engineers from both colonial and domestic sources. The USA, as a former colony of Great Britain and early ally of France, developed an unusual commitment to a 'balance' between practical and theoretical knowledge, with a pendulum that swings back and forth depending upon the dominance of images characterising the most immediate threats to future 'progress'. In Egypt, one finds evidence of influences not only from the French, British, Germans, and, more recently, the Americans, but also efforts to recreate the past glory of Egyptian civilisation and to work toward an economic union of Arab states. In Japan, although never a European colony, one finds evidence of British and German models influencing engineering education beginning in the Meiji period, as well as a strong American influence after World War II.

Each country-based module grapples with roughly four sets of questions:

- how did the nation–state emerge and what has counted as 'progress' or 'advancement'?
- how have engineers emerged, what has it meant to be an engineer, and what sorts of knowledge have engineers valued?
- what counts as a typical career trajectory, including education and worklife?
- what trends are emerging in response to the new emphasis on industrial competitiveness?

5 Continuing education through multimedia modules

A three-year collaboration between the authors and Virginia Tech's Video Broadcast Services has made five Engineering Cultures modules available on CDs in multimedia form, including materials in France, UK, Germany, Japan, Soviet Union/Russia, and the USA. Each module offers a 15-minute *Welcome*, a 60-minute *Introduction to Engineering Cultures*, and a series of three–four classes, each 40–60 minutes in length. Each class is built around a videotaped presentation, drawing from a previously researched and drafted script, and supported by text and images that enhance learning of key concepts.

Modules also make an effort to place learners 'in contact' with engineering students, engineers, and other people from the country under consideration. For example, the Germany module contains audio clips of German engineers describing their education and practice traditions and images of German engineering students working in industrial workshops. The France module has audio clips of working engineers and engineering students, as well as images of engineering students at the *grandes écoles*. The Japan module includes as co-presenter a female Japanese engineer, and former employee of

IBM Japan, detailing her experiences in engineering education and practice, supplemented with her own drawings as illustrations. The Soviet/Russia module includes numerous colour propaganda posters from the Stalinist era. Work is underway on new modules on Mexico, Korea, Greece, Taiwan, and India, as well as on moving all the modules to streamed video.

In extensive testing of these modules in four semester-long, 100% online undergraduate courses, 70–75% of enrolled students reported that they would or might do it again, while only 9–13% said they would or might not and 15–17% were unsure. Median student performance on a pilot multiple choice pre/post test indicated an increase from 54% to 77% correct. Qualitative assessments of student discussions, instructor meeting notes, and student responses on a final homework assignment asking them to 'describe and assess who they are now after having taken the course' illustrated the extent to which the vast majority of students found the material interesting, helpful, and provocative. In some cases, participating in Engineering Cultures online became a profound, life-changing experience.

A pilot continuing education test of individual modules with two engineers from Southern Nuclear has also yielded positive results. In reviewing the Soviet/Russia module, Skip Kitchens, General Manager, wrote,

> "The daily lessons on the CD were quite good … This mini-course provided me with a very different image of the Soviet Union than I had previously … The relationships between technology and politics has definite lessons for other countries. This course has caused me to think!"

Reporting that the mini-courses could be helpful in his company's diversity programme, Kitchens concludes,

> "This course could be useful for engineers who interface with customers, suppliers, or employees from foreign countries. It could help students understand and value different backgrounds, ideas, and perspectives."

In reviewing European modules, Steve Swanson, Engineering Manager, wrote,

> "This was an excellent course. I would like to complete the remainder as time allows. Based on this course, I have a deeper understanding of my own role inside my own company, in addition to the objective to understand other country's engineering cultures. It was well worth the time."

At present, working engineers must use the Engineering Cultures multimedia modules on their own. The next step is to build a formal mechanism for engineers to earn continuing education credit for completing Engineering Cultures modules and online quizzes, possibly through an existing CEE provider. To this end, the authors have developed pools of quiz questions for each class day of each existing module.

In sum, dramatic increases in the internationalisation work call for comparable increases in the attention given to CEE for transnational careers. At present, engineers largely have to sort out the difficult questions for themselves. An approach based in the liberal arts helping engineers understand what it means to be an engineer in different countries can address the problem directly, provided it can scale up adequately.

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