be fully appreciated as failings that detract from the optimum operation of the business and indicative of today's competitive pressures, businesses which depend on engineers must first find and recruit competent engineers and show appropriate appreciation of their engineering skills.[15]

In an age of lean manufacturing and just-in-time assembly, some of the same ideas can influence educational thinking, especially when they offer the potential for efficiency improvements. The economic imperative can make such pressures attractive, but this can conflict with fitness for purpose, which has forced all activities to function at increasingly leaner levels. This in its turn has led to employers looking to fill positions with people who potentially have a minimum 'latency time' before contributing profitably to the operation of the business. In the current era, 'the knowledge economy' – the effective utilization of education – is essential, but at the same time we also need to recognize its broader context.

Much debate continues about the nature, context and curricula of undergraduate engineering education. Amongst other influences this is driven by the rapid expansion in knowledge and changes in practices, concerns about attracting students into the engineering profession and the changing requirements of employers. Unfortunately, these debates are frequently conducted without reference to a wider concept that a first degree should be just the start of a career-long education process. However, there are also inherent uncertainties and instabilities associated with CEE, which it is all too easy to down play or overlook. Because the funding processes are different, insufficient thought is given to the whole lifetime learning process of the engineer and the implications this might have for initial formation, because the funding processes, are different. No initial education can equip an engineer for life yet there is a large discontinuity between initial and continuing education, which does not serve the profession well. How a skill shortage is identified, how a professional learns and how companies support this process is insufficiently studied and yet can reveal some interesting information.[16]

In Europe, what has become known as the 'The Bologna Process', has energized a debate on the initial education and formation in the professions, with an emphasis on developing a harmonization of educational systems, thereby facilitating greater mobility, for example between bachelor and master degree programmes. In part, this process has been beneficial in helping to deepen the understanding of the development of the core competencies expected of a professional engineer.

15 Jones, M, E. 2003. *Challenging The Education of Engineers for the Globalizing Economy*, Proceedings of 31st Annual SEFI Conference, Global Engineer: Education and Training for Mobility, Porto Portugal, 7–10 September. A. Soeiro and C. Oliviera (eds.), ISBN 972-752-063-4, pp.102–106.

16 Jones, M. E. 2004. *Analog Design: The Development of Essential Professional Expertise*, Proc. 9th WCCEE, Tokyo (May 2004), pp. 231–236.

Although it may be challenging to address the issues associated with harmonization in initial formation, this pales into insignificance when the necessity, form, structure and financial responsibility for continuing engineering education are considered. While the current rather ad hoc situation for Continuing Engineering Education has evolved gradually, it is also unlikely that there will be any quick solution to establishing a more structured approach to its delivery and receipt.

Enhancing quality

In many countries there is a well regulated quality assurance process for assessing the initial education provided in universities, although the understanding and interpretation of the word often varies.[17] Although these same institutions frequently provide CEE and CPD they are only one of many providers, and the same quality assurance processes are not available. With this in mind, the EU and United States, via the Atlantis Programme, have funded a transatlantic programme called 'Development of Accreditation in Engineering Training and Education' (DAETE).[18] Using the model of the European Foundation for Quality Management (EFQM), a method has been developed for establishing a set of quality metrics against which providers can be evaluated. This is now being adopted by the International Association for Continuing Engineering Education (IACEE) and, hopefully, as this approach starts to become more widely appreciated, a robust vehicle for quality monitoring and CEE provider accreditation will be established, which will help contribute to improved standards for CEE globally.

7.2.7 Brain drain, gain, circulation and the diaspora

Jacques Gaillard

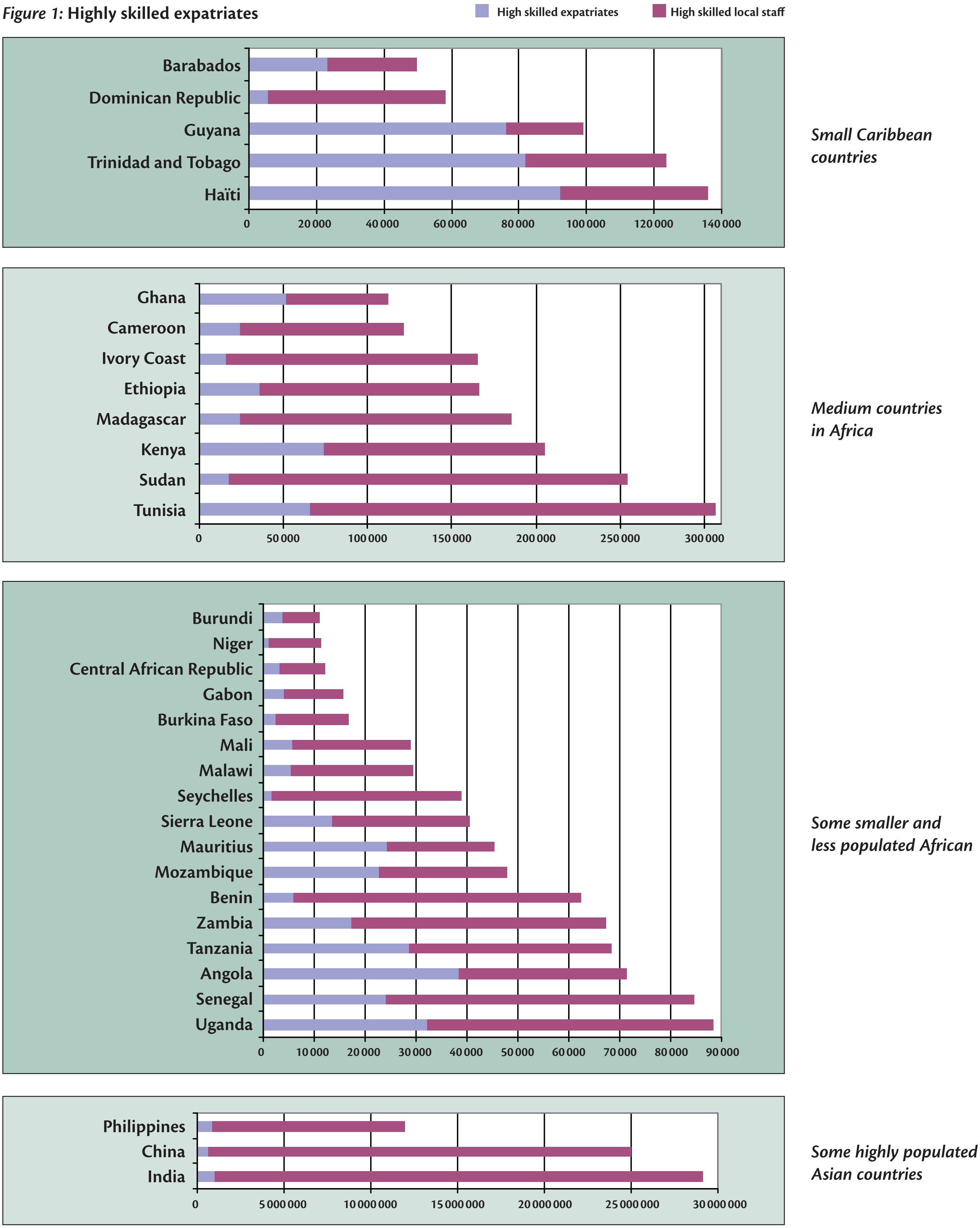
The movement of engineers and scientists throughout the world is as old as the practice of engineering and science. The contrast in opinions on the effects of international scientific migration (ISM, which includes engineering) derives from its character as a polymorphic phenomenon whose costs and benefits have been frequently mentioned but never thoroughly evaluated. The question is still open.

There are several relatively recent phenomena that revived the debate on ISM perceived as a brain drain by many countries, including developed countries in Europe: the collapse of the communist system and the migration of Soviet and Eastern European professionals to other professions and countries; the large scale return of highly qualified engineers and scientists to

17 Goodlad, S. 1995. *The Quest for Quality; Sixteen Forms of Heresy in Higher Education*, SRHE and Open University Press, Buckingham UK. ISBN0-355-19350-1

18 EU-US Atlantis Programme 2006 Contract 200-4563/004-001

Figure 1: **Highly skilled expatriates**



South East Asian countries and more recently China; and the fact that the countries affected by the brain drain attempted to organize their engineering, science and technology (EST) diasporas into institutionalized networks, so as to facilitate the circulation of people and information and initiate collaborative research programmes between the national and expatriate scientific communities. Yet a number of developing countries remain typical examples of the recurring brain drain problem.

One of the main difficulties is to measure migration. Due to the often unclear definitions – the fact that engineering, science and technology is usually aggregated together despite the diversity of disciplines and levels – there is no mechanism for observing movement. This leaves us with unreliable and non-standardized statistics. The fact that departures are recorded (to some extent) but returns are not, may in part explain certain overestimated figures for the brain drain.

The OECD has contributed to creating a tool to measure migration: a database[19] on migrants and expatriates constructed from information gathered in twenty-nine of the thirty OECD countries.[20] These data make it possible to identify highly qualified migrants or emigration rates for highly educated persons by country of birth or origin. The emigration rate of highly educated persons by country of origin is calculated by dividing the highly educated expatriate population in a given country by the total highly educated native-born population of the same country. Highly educated persons are defined as persons with a tertiary level of education (which includes in all disciplines, including engineering and science). This database can be used to produce the total number of highly skilled expatriates and the percentage of highly skilled expatriates by country of birth (Dumont and Lemaître, 2005).[21] The results show that the percentage of highly skilled expatriates is quite high in the small and medium countries of the Caribbean and Africa (Figure 1). As might be expected, countries that suffer long civil wars (e.g. Haiti, Angola, Mozambique) and countries composed largely of migrant populations (e.g. Mauritius) are particularly affected by brain drain. A recent study in Lebanon showed that at least half of Lebanese engineers and scientists lived outside the country (Gaillard, 2007).[22] The bigger countries in Africa, Asia and Latin America are, in absolute terms, severely affected by the emigration of their highly skilled personnel, though its relative importance may be less significant. The OECD data estimate indicates that India has more than one million highly skilled expatriates, but this represents less than 4 per cent (3.43 per cent) of its total highly skilled population. The figure for China, with a total of more than 600,000, is less than 3 per cent (2.61 per cent) of its high skilled population.

Can the EST diaspora help mitigate the brain drain?

Against this backdrop, recent policy documents and political discourses assert that the hundreds of thousands of engineers and scientists expatriated from developing countries should no longer be seen as a bane but, on the contrary, may constitute a boost for many of them. The idea is spreading rapidly in many developing countries and seems to be unanimously supported; that the 'EST diaspora' will make up for the shortcomings and weaknesses of the national engineering and scientific communities. This idea, attractive as it may be, needs to be approached with caution.

People advocating the use of the diaspora see it as a way to mobilize the country's emigrant engineers, scientists and technologists all over the world to the benefits of their home countries thanks to improved access to engineering and scientific information and expertise through extensive social, technical and professional networks, increased training opportunities, and the development of collaborative projects between expatriate and domestic engineers and scientists. The diaspora model is appealing to politicians and policy-makers since it appears to offer a low-cost, self-managing, efficient, easy solution. The option is also appealing to expatriates who feel motivated by an opportunity to contribute to the development of their country of origin from a foreign location, where they may want to remain without feeling guilty. Over the last decade, an increasing number of countries have undertaken initiatives to create databases of expatriate engineers and scientists, and to mobilize, organize and reconnect their scientists abroad with the scientific community at home. Yet, the sustainability and effectiveness of this approach remains to be proved, and the fate of some important EST diasporas (e.g. Red CALDAS in Colombia, and the South African Network of Skills Abroad in South Africa) already shows that the promise of the diaspora approach is more difficult to achieve than some may imagine. These important institutionalized initiatives need to be evaluated.

The 'diaspora model' will never be a low-cost, self-sufficient answer to Africa's engineering and scientific needs. To be successful, a number of conditions need to be fulfilled (Gaillard and Gaillard, 2003).[23] Its effectiveness depends substantially on the internal dynamics of the home-based engineering and scientific communities. A network of expatriates is at best an extension of a national engineering and scientific community; it can never be a substitute. Efforts should therefore, first and foremost, focus on strengthening national engineering and scientific capacity particularly through training, recruiting

19 The construction of this database draws on the work of Baro and Lee (2000) and of Cohen and Soto (2001).

20 Iceland is the only country that did not participate.

21 Dumont, Jean-Christophe and Lemaitre, Georges. 2005, *Counting Immigrants and Expatriates in OECD Countries: A New Perspective*, Conference on Competing for Global Talent, Singapore Management University, Singapore, 13–14 January.

22 Gaillard, J. 2007. *Evaluation of Scientific, Technology and Innovation Capabilities in Lebanon*. Report for ESTIME/European Commission (Rigas Arvanitis Coord.), 55 pages.

23 Gaillard J. and A.M. Gaillard. 2003. *Can the Scientific Diaspora Save African Science?* SciDev Brain Drain Dossier. http://www.scidev.net

and retaining the next generation of scientists. Failing this, the diaspora model will be no more than a smart cloak that hides shabby clothes.

7.2.8 Industry Capacity Index

Peter Boswell

The FIDIC National Industry Capacity Index

Strengthening private sector national consulting industries is essential for developing sustainable, knowledge-based job opportunities that generate wealth. The International Federation of Consulting Engineers (FIDIC) has identified a lack of information at the national industry sector level on capabilities, staff and facilities, and the attendant lack of visibility, as a major factor impeding capacity-building. This lack has led to an unsatisfactory utilization of the industry's capacity, and made it difficult to identify where resources should be directed to promote capacity-building.

One approach for highlighting the needs was to develop a capacity benchmark for the national consulting engineering industry sector. However, without careful design, benchmarks may focus on inappropriate factors. The challenge was to identify a limited set of indicators that met the needs of a specific audience. In addition, indicators must be reliable, efficient and accurate, thus largely based on existing and standard reporting practices and comparable between different countries.

FIDIC believes that reliable benchmarking at the national industry sector level requires a systems approach that organizes data and reporting in a coherent manner.

The benchmarking cube

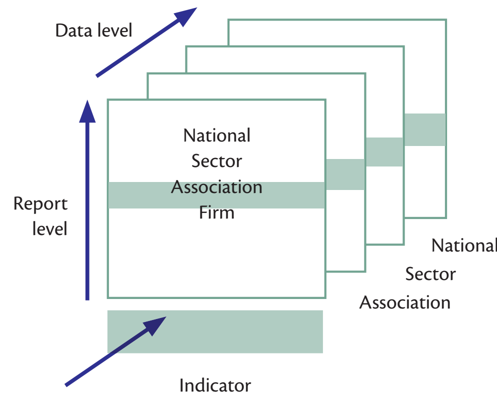
FIDIC's system is based upon data provided to FIDIC Member Association firms in several countries. The system could be represented in terms of a simple cube. One axis comprises the 'Data Level', where relevant data for the various indicators takes two forms:

- Firm Level data: confidential information provided by firms within a national industry sector to a national industry sector organization.
- National Level data: publicly available information generally collected by government, or extracted from data reported at the national level by government and groupings of industry sectors.

The system focused on two types of reports, namely national industry capacity and firm benchmarking. Consequently, a second axis for the cube represented the 'Report Level'.

The third axis of the benchmarking system represented the various indicators, as illustrated in Figure 1.

Figure 1: **The benchmarking cube**



The tools commonly used by the national industry sector and by firms in a variety of business processes were then analysed to identify suitable indicators. These tools included: a) company reports; b) registration systems for a firm's capabilities; c) national firm benchmarking and industry surveys; d) calculations of fee scales. It was found that indicators could be organized into the four dimensions of the Balanced Scorecard:

- Financial management
- Human resources
- Client relations
- Business operations

FIDIC therefore proposed that for benchmarking capacity at the national industry sector level, indicators should be:

- Distributed uniformly across the four Balanced Scorecard dimensions.
- Designed to mainly report at the firm level and at the national industry sector level.
- Generated by consolidating data from the firm level and by extracting data reported at the national industry sector level.

In order to ensure a balanced set of indicators, one, two or more indicators must be generated for each combination of Data Level and Report Level. The simplest is to start with a single indicator for each combination, giving a total of sixteen indicators.

Verifying that indicators are balanced

The best way to verify that the proposed capacity indicators were balanced was to compare them with indicators that

UNESCO Report

Engineering: Issues Challenges and Opportunities for Development

Produced in conjunction with:

- World Federation of Engineering Organizations (WFEO)
- International Council of Academies of Engineering and Technological Sciences (CAETS)
- International Federation of Consulting Engineers (FIDIC)

UNESCO Publishing

United Nations Educational, Scientific and Cultural Organization

Published in 2010 by the United Nations Educational, Scientific and Cultural Organization
7, place de Fontenoy, 75352 Paris 07 SP, France

ISBN 978-92-3-104156-3

Cover photos: Drew Corbyn, EWB-UK; Paula West, Australia; flickr garion007ph; Angela Sevin, Flickr; imageafter; Tony Marjoram; SAICE; UKRC; Joe Mulligan, EWB-UK.

All full-page images from chapter introduction pages are by kind courtesy of Arup.

Typeset and graphic design: Gérard Prosper
Cover design: Maro Haas
Printed by: UNESCO

Printed in France