The general public has a highly mistaken view of what engineers do, often believing they merely fix or build things. Moreover, people typically give the profession just a middling level of prestige, below that of scientists, teachers, nurses and doctors.

The authors assert that engineers should better understand their responsibility to society and align themselves with the notion of “the global engineer.” By helping identify the causes of society’s challenges and creating and applying logical and effective solutions, engineers can help the public better understand engineering’s role and value to society. A more accurate perception of engineering, as well as promotion of the profession, may also make engineering more appealing as a career.

Changes being implemented by the Canadian Engineering Accreditation Board (CEAB) place a greater importance on understanding the role of engineers in society, as well as on professional ethics, accountability and communication and teamwork skills. This shift will also help correct the inadequate skills employers have identified in new graduates.

Engineers Without Borders Canada recently spearheaded an international effort to define the term global engineer. Among the key identified attributes were a highly defined sense of social responsibility and ethics, entrepreneurship, and the ability to deal with complexity and systems thinking.
society. By definition, engineering is a service profession. Day-to-day engineering, however, is more often focused on technological rather than human concerns.

In addition to a poor understanding of engineering, there is also a poor public perception of engineering. A large disparity exists between how engineers want to be perceived versus how people actually view the profession (Baranowski and Delorey, 2007). When the relative prestige of engineering is ranked among other professions, it falls near the middle, and far below doctors, nurses, scientists and teachers (Harris Interactive, 2006).

Public perception is framed partly by an emphasis on defining engineering by a limited set of required skills (e.g. mathematics and science). One US study of teenagers found that “many students believe engineering work is sedentary, performed mostly on computers, and involves little contact with other people” (National Academy of Engineering, 2008). Braham notes that engineers have frequently been described as having “poor social skills” and being “self-absorbed loners, rigid with a one-track mind” (Braham, 1992). Public polls also reveal that people believe engineers are not as engaged with societal and community concerns when compared to scientists (Harris Interactive, 2004; Baranowski and Delorey, 2007).

Unfortunately, the public view that we, as a profession, are technology-driven is generally true. Engineers are highly skilled in mathematics, science and technology; these are often the aspects of engineering that excite them. Moreover, this perception attributes the types of students who are interested only in mathematics, science and technology, further reinforcing the stereotype.

Too often, engineers will spend an inordinate amount of time and effort solving technical problems, but little time connecting these activities to the goals of the projects they are working on. These engineers have become nothing more than technical skill-applying automata, forgoing the critical thinking required to understand the context in which their skills are useful. In addition, as with most people, engineers tend to gravitate to their core competencies, playing to their strengths, avoiding their weaknesses (e.g. soft skills, cultural understanding, economics).

This paper asserts that engineering needs to be much more aware of its responsibility to society. Engineers need to ensure they focus on human concerns. The profession shares responsibility for understanding the challenges faced by society, identifying their root causes and helping to design and implement sensible, innovative and effective solutions to overcome them. The best way to achieve this objective is to embrace the concept of “global engineering.”

A new engineer for the 21st century

Engineers need to embrace a broader vision of their professional role as a response to two ineradicable developments: globalization and global issues reaching critical levels (e.g. global warming, extreme poverty, rising health care costs). All cry out for engineering input.

These issues are by no means new to the world, or to engineers, but their current magnitude and scope require more innovative responses. As the world becomes more complex and interrelated, so do the problems engineers face. The engineering profession and individual engineers need to adapt or else risk getting lost in these global changes, thus abandoning our social responsibilities.

Partly in response to these needs, the CEAB recently revised its accreditation requirements. Attributes that graduates from an accredited program should possess are now specified in the latest accreditation documents (CEAB, 2008) and are being phased in over the next five years (see Appendix 1).

These new graduate outcomes represent a shift in the CEAB accreditation philosophy from focusing exclusively on the class hours that comprise engineering programs to investigating the competencies of undergraduate engineering program graduates to see if they possess the desired attributes. The new outcome-based requirements put a greater emphasis on ensuring that graduating engineers understand the role of the engineer in society; professional ethics, accountability and equity; and the impact of engineering work on society and the environment.

But the CEAB did not stop there. In revising its graduate attributes, the CEAB also responded to a set of complaints from the profession and employers. In the past decade, there have been increasing concerns about the lack of professional awareness and low levels of communication and teamwork skills among engineering graduates (Rugarcia et al., 2000). Indeed, the most common criticism of recent graduates by industry leaders and alumni is that they lack communication skills and the ability to work in a team (M echefske et al., 2005). As a result, the CEAB now requires that graduates demonstrate competence in teamwork and communication skills.

Why “global engineering”?

As technology develops, especially in the fields of communication and transportation, it links even more closely every part of our rapidly shrinking world. We are experiencing increasing global interdependence, with engineers expected to exercise leadership in confronting the world’s most dynamic and complex challenges. Engineers are uniquely positioned to offer solutions because of their creative problem-solving abilities and systems thinking.

However, there needs to be an increase in engineers’ core capacities that will enable them to work more effectively on global issues. The world needs “global engineers.” In addition to the graduate attributes specified by the CEAB, the global engineer must also demonstrate additional characteristics and qualifications.

Over the past three years, in collaboration with engineering faculty members from across Canada and around the world, and with industrial leaders as well as engineering students, Engineers Without Borders Canada has led an effort to define the global engineer. Some of the key attributes are:

- superior communication skills and understanding across different cultures and languages;
- a facility for multidisciplinary and interdisciplinary teamwork;
- a well-developed sense of social responsibility and ethics, with due consideration in his/her personal and professional activities;
- being entrepreneurial; and
- an ability to deal with complexity and systems thinking.
As previously noted, organizations are placing increasing importance on soft skills. Interestingly, May and Strong, 2006, show an overwhelming majority of engineering graduates rate themselves as being highly competent in communication, showing a large disconnect in expectations of these skills.

More importantly, acquiring these skills has not traditionally been seen as part of an engineering education. But with the evolving nature of international business and the internationalization of engineering projects, not only must global engineers be effective communicators, they must also communicate effectively across different languages and cultures. For example, with the world’s hunger for resources and the expansion of extractive industries, engineers are working more frequently in international contexts in collaboration with local workers, communities and governments. The success of these international projects, and the assurance that these projects will be implemented in a socially and globally beneficial manner, hinges on the ability to communicate effectively across cultural divides.

While engineers have operated historically in silos, often disengaged and disinterested in challenges that are not completely within their field, there is an increasing need for them to work in more multidisciplinary teams. This includes not only with engineers in other subdisciplines, but also with people outside of engineering (e.g. policy-makers, medical doctors and economists).

In addition, there is a need for engineering to become increasingly interdisciplinary. Here we distinguish multidisciplinary from interdisciplinary. The former refers to people from different disciplines working in a cooperative manner while still focusing on their core competencies. The latter requires individuals on a team to have overlapping core competencies. An engineer requires a broader knowledge and understanding of other disciplines (e.g. public policy, environmental issues, social issues, business/marketing) to ensure appropriate technologies are accepted and developed. Without such a broader appreciation, these new technologies become “merely interesting inventions that are not adopted” (Beder, 1999).

For example, in the area of sustainable energy, there exist some excellent engineering solutions, such as solar and wind power. However, their impact has not been fully realized with such upfront costs as infrastructure setup being a common barrier. Long payback periods also deter adopting solutions, despite the apparent financial savings in the long term (Brown, 2001). (See “Found in translation: A new language for energy efficiency retrofits” on p. 9 in this issue.) The potential positive environmental impact seems to be secondary to these fiscal concerns.

Engineering solutions that help sustain the environment can remove these economic barriers by reducing costs and improving efficiency. Since changes in public policy can help expedite the adoption of new technologies, engineers must become advocates within the policy arena. It is a matter of self-interest that they do so, as well as demonstrating that they are acting as “good” engineers, working “for the betterment of society.”

The responsibility of engineers should not be simply to analyze the potential impact of their activities. Social responsibility implies that engineers should also consider which activities to engage in. When considering a needs-driven approach, centred on human concerns, there is an apparent disparity reflecting the chasm between the world’s haves and have-nots. This disparity is captured by social activist Paul Polack’s conclusion that an overwhelming majority of engineering and design cater to the richest 10 per cent of the world’s population. This finding has spurred the creation of the “Design for the other 90%” movement (Polack, 2008).

Global engineers acknowledge that their development efforts must take into account socioeconomic realities and be sensitive to cultural differences. They are aware that numerous projects fail when solutions that work in developed countries are applied to developing nations (as well as applying solutions that worked in one developing nation to another developing nation, without consideration of the contextual differences). Instead, a holistic approach to design must be employed, consequently involving the affected communities throughout the design process.

For his part, Baylor University engineering professor Byron Newberry raises what appears to be a dichotomy of engineering globalization requiring methodological localization. While engineering scientific principles are universally applicable, other elements (e.g. organizational, economic and environmental issues) often direct the engineering process (Newberry, 2005).

A global engineer’s success will hinge on his or her ability to identify unconventional emerging opportunities. This capacity is based largely on strong entrepreneurial skills. By clearly seeing the needs of the world and applying technical innovations in response, as well as effectively operating across different cultures and languages, the global engineer will be able to expand an engineer’s service to the world.

The traditional realm of engineering is concerned with innovative solutions to complicated problems; that is to say, large-scale problems Considering a needs-driven approach, centred on human concerns, there is an apparent disparity reflecting the chasm between the world’s haves and have-nots. This disparity is captured by social activist Paul Polack’s conclusion that an overwhelming majority of engineering and design cater to the richest 10 per cent of the world’s population. This finding has spurred the creation of the “Design for the other 90%” movement (Polack, 2008).

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that can be deconstructed into parts that can be fully modeled, understood and overcome. But today’s engineering problems are moving from the complicated to the complex. Using current global realities as an example, complexity can be seen in the dimensions of time, geography and outcomes of emerging engineering problems, as illustrated in Figure 1.

To use a practical example, engineering projects have moved from designing a bridge to designing a bridge in a developing country with an emerging democracy using local labour. Engineers need to become comfortable working in the ambiguity of these complex environments with seemingly open-ended problems. Engineers need to take a disciplined approach: understanding what parts of the system they do and do not have knowledge of and making testable assumptions on these unknowns based on experience.

**How to produce a global engineer**

The path to developing more global engineers is as difficult as the challenges these engineers will face. Despite the array of formative influences (e.g. peer groups, early formed personal values, work experiences, etc.), one thing is certain– there is a tremendous opportunity to shape these future global engineers by enhancing their formal education.

However, changes to the engineering curriculum are fraught with controversy. Some faculty and administrators see the current curriculum as already being overcrowded and in need of reform to meet traditional education outcomes. Others view the current system as adequate or are hesitant to enter conversations over its enhancement due to the curriculum’s complexity. But given the new CEAB accreditation process, the time is right to begin a substantive and substantial curriculum review.

With respect to developing global engineers, there are four obvious opportunities. The first is exploring possibilities for integrative enhancement, combining the traditional teaching approach with new elements that emphasize characteristics of the global engineer. These integrations can vary in form, from reinforcing elements of the global engineer in all aspects of a particular course, to adding a single question on an assignment prompting students to think beyond that traditional space and into the new, global engineering thought space.

The second possibility for enhancement is moving towards the creation of interdisciplinary options/programs. We have already seen an increase in programs that merge engineering with business and management in response to a growing need in technology management. Similar synergies with engineering can be found in other disciplines, such as public policy and international affairs.

Third, the creation of innovative complementary studies electives can help present these concepts in a more focused manner. This option is the most immediately applicable and represents the easiest first step down the path of global engineering education.

Finally, undertaking additional research into engineering pedagogy, with the focus on including global engineering concepts, should produce potential course enhancements, possible new courses and best practices for implementation. Due to the complexity of engineering education, no single option presented here should be considered a silver bullet. It is only through a combination of activities that we will be able to equip our future engineering graduates with the knowledge, skills and attitudes to be successful in the new global economy.

**Conclusion**

A better public understanding of engineering will help improve perceptions of the profession and may encourage more students to pursue an engineering education. Currently, the technology-centred perception results in attracting mostly technology-savvy individuals.

The engineering curriculum and the type of person choosing engineering are not unrelated. Indeed, the immense load of technical courses feeds prospective students the perception of engineering being a purely technically centred career (Beder, 1999). As a result, many potential students feel they are not smart enough to become engineers (National Academy of Engineering, 2008). In addition, other students may opt out of engineering because they do not see how engineering impacts societal concerns. The recent changes in the CEAB accreditation requirements, particularly the inclusion of the graduate attributes, can help motivate the necessary curriculum change.

When examining various messaging themes about engineering, it is interesting to note that the messages that convey “engineering makes a world of difference” were found to be the most appealing to respondents in an online survey of 3600 individuals in the US. The message theme that “engineering connects science to the real world” was found to be the least appealing (National Academy of Engineering, 2008).

Canada’s high-potential youth are increasingly engaged in their communities and are actively seeking careers that positively contribute to society, sometimes making compromises in their salaries. There is also a gender bias, with women being more attracted to altruistic careers. Within engineering, there is typically a higher enrolment of women within more social programs, such as environmental and biomedical engineering

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**Appendix 1**

**CEAB graduate attributes**

In 2008, the Canadian Engineering Accreditation Board (CEAB) mandated that engineering program graduates must exhibit the attributes under the following headings:

- a knowledge base for engineering;
- problem analysis;
- investigation;
- design;
- use of engineering tools;
- individual and team work;
- communication skills;
- professionalism;
- impact of engineering on society and the environment;
- ethics and equity;
- economics and project management, and
- life-long learning.
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(Grasso, 2002). Indeed, men rated the messages of “engineers make a world of difference” and “engineers are creative problem-solvers” nearly equally high, whereas the top two messages appealing to women were “engineering makes a world of difference” and “engineering is essential to our health, happiness and safety.”

Changing perceptions is, of course, ineffective if the perception does not reflect reality. But as the world is changing, the concept of the global engineer is moving beyond the profession’s traditional role. The engineer’s role in society is no longer, if it ever was, limited to solving technical issues. Today, broader issues with society-wide and global implications require the profession’s attention.

Appendix 2

Characteristics of the global engineer

Through focus groups conducted by Engineers Without Borders with engineering faculty, students and industry leaders, the following characteristics of the global engineer have been identified. The faculty of engineering at the University of Toronto has also attempted to define the characteristics of Global Engineers reaching a similar and more comprehensive definition, presented below (Cheng et al., 2008). (Differences between the global engineer characteristics and the CEAB graduate attributes are in bold.)

A global engineer is an engineer who:

- understands the broad, bigger-picture context of engineering work, including cross-disciplinary aspects, as well as the business and social implications;
- has expertise in a specific field, but is comfortable in many engineering disciplines and able to work in an interdisciplinary way;
- is a problem solver and is creative;
- can adapt to new situations, deal with complexity and is skilled at systems thinking;
- is able to collaborate on a global basis, including knowledge and/or understanding of people, culture and language, along with knowledge of collaboration techniques and software;
- is able to communicate effectively both orally and in writing in English, and is able to communicate across language and cultural differences;
- has an understanding of sustainability efforts and the ability to factor environmental impact and energy-use characteristics into all aspects of his/her work;
- is up to date on current world issues and emerging trends and is constantly expanding his/her skills to be able to respond to these issues appropriately;
- has a well-developed sense of social responsibility and ethics, with due consideration in his/her personal and professional activities for the world and society; and
- is entrepreneurial and is prepared to work with a varying level of resources and in various types of organizations in many different roles.

Increasing the number of Canadian engineering students and expanding their professional vision and capacity is vital to maintain a high degree of professional innovation. Such developments are also essential if our engineers are to remain competitive worldwide in the face of an onslaught of engineering graduates from other countries, such as China and India. China has more than doubled the number of graduates in engineering, computer science and information technology between 2000 and 2004 (Wadhwa et al., 2007). At the same time and, partly as a result, North American engineering is facing a potential crisis from offshoring, similar to what has afflicted the manufacturing and service industries.

Researchers Martin Kenney and Rafiq Dossani suggest two responses for North American engineers faced with this new competition. First, instead of relying solely on technical competencies, engineers should, as global engineers, develop the ability to coordinate projects that have a global workforce. This includes an understanding of local custom and laws, foreign business capabilities and sensitivity to cultural differences.

Second, the global engineer should be entrepreneurial, not only being innovative in technology but also being able to take advantage of new business venture opportunities. “By creating new value, increased entrepreneurship is the antithesis of the zero-sum game” (Kenney and Dossani, 2005).

As Toronto Globe and Mail columnist Jeffery Simpson has aptly noted, “Never has the world meant more to Canada; never has Canada meant less to the world.” Traditionally, engineers have viewed themselves on the sidelines of this global engagement challenge, innovating in their local or national communities but not venturing onto the world playing field. However, it is the development of global engineers that represents an excellent opportunity for both engineers and Canada to make an impact on the world stage.

The world is changing. Engineers must acknowledge this reality and act appropriately. The opportunity for Canadian engineers has never been more promising. We must now find the courage and determination to turn our professional dreams into global realities.

References


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1. Adrian D.C. Chan is an associate professor with the department of systems and computer engineering, Carleton University. His research interests are in biomedical engineering, including biological signal processing, pattern recognition, assistive devices, non-invasive sensors and electronic noses. Chan, who received his PhD in electrical engineering from the University of New Brunswick, is also the Carleton program director for Shad Valley, a program for senior high school students aimed at developing their intellectual excellence and leadership while challenging them to meet the highest standards of ethical conduct, social responsibility and environmental sustainability. He is also faculty advisor for the Carleton Engineers Without Borders chapter.

2. Jonathan M. Fishbein is the program coordinator for curriculum enhancement and global engineers at the Toronto-based Engineers Without Borders (Canada). His responsibilities include coordinating EWB’s post-secondary curriculum initiatives at universities across Canada and developing EWB’s vision for the future of engineering education and the training of global engineers. He holds a master of applied science in systems design engineering from the University of Waterloo.

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**Found in translation: A new language for energy efficiency retrofits**

By Joshua M. Pearce, PhD,1 Tom Carpenter, MA, MPA,2 and David Denkenberger, MSE3

**Executive summary**

Engineers and corporations eschewing energy conservation measures (ECMs) because payback times are considered too long may inadvertently forego sizable savings and reductions in greenhouse gas emissions. A more accurate way to gauge the true benefit of an ECM is to weigh the cost over the ECM’s life expectancy. Organizational accounting methods can also dissuade some decision makers from recommending ECMs, particularly when their department is expected to shoulder the cost while another department is credited with the savings. Rather than viewing ECMs as expenditures by individual departments, engineers and companies should regard them as investments for the entire organization— even ways to make money. ECMs can also be profitable if a corporation has to borrow money to implement them, provided the ultimate savings outweigh the purchase price and borrowing costs.

The authors present a straightforward formula to calculate an ECM’s return on investment, based on factors such as the net principal cost and the expected annual savings. The projected savings are expressed as a percentage, which is more representative of the actual cost savings and much easier for decision makers to understand.