VIEWPOINT

"Preventive engineering" for a better tomorrow

Cloning, genetically-modified foods, digital communication... the engineering profession is achieving results, but at what cost? We have to work to be more sensitive to how innovation affects human life, society and the environment, says Willem H. Vanderburg. The University of Toronto engineering professor says changes for a better future start at the undergraduate level.

by Willem H. Vanderburg, P.Eng.

Specialists of all kinds are now engaged in making things "better" in every sphere of life. These specialists make decisions whose consequences fall mostly outside their domains of competence, to be dealt with in an after-the-fact manner by others in whose specialties these undesired effects fall.

As a result, the "system" first creates problems and then "solves" them by adding devices or services to compensate for or mitigate the undesired effects. We first produce pollutants and then install control devices to remove the most dangerous ones from waste streams and then landfill them, which merely transfers these pollutants from one medium to another without solving the real problem. We feverishly continue to restructure corporations to improve the productivity of labour with the result, as shown by socio-epidemiology, that human work has become one of the primary sources of physical and mental illness. The situation has compelled us to add social and health services at great expense. Since these do not prevent the problems either, their costs can only grow, to the detriment of all parties.

It is virtually impossible to get to the root of any problem in order to prevent or minimize it. The system displaces rather than resolves the problems it creates, thereby feeding on its own mistakes and trapping us in what I call "the labyrinth of technology."

The following slightly elaborated historical example will further illustrate the point.

A group of experts examining a hunger problem in a Colombian valley under the auspices of the United Nations tackled the problem this way: The nutritionist made an inventory of all the foodstuffs grown in the valley in order to determine the most nutritious diet possible, supplemented it as required, and made the appropriate recommendations. The specialist in community health suggested that these recommendations would not solve the problem because the inhabitants of the valley suffered from intestinal parasites resulting in diarrhea and their inability to absorb a nutritious diet. Instead, this specialist recommended that the water supply be improved, sewage treatment be started, and basic healthcare provided.

The economist smiled politely, suggesting that the inhabitants did not have these things because they lacked the resources, and that these could only be created by economic development based on cottage industries and some inhabitants working outside of the valley to send money to their families. The agronomist on the team recommended instead that the inhabitants be taught modern agricultural methods to enable them to grow enough food for themselves and to sell the surplus to generate income enabling them to procure the above-mentioned necessities of life. The political scientist firmly disagreed. All these things were not happening because the hungry people in the valley had no political voice, and this would not change until they were empowered by forming a political party.

I could go on with the diagnoses and recommendations of the sociologist, the demographer and an expert in systems. However, the point is obvious: Each expert paints a picture of the situation by putting those aspects that correspond to his or her specialty in the foreground and everything else in the background, thereby creating incommensurate diagnoses and recommendations.

Each and every expert has the answer, but clearly does not know what the question is.

In the absence of a science of the sciences, it is impossible to scientifically integrate the findings of different specialties to arrive at a comprehensive interpretation of the situation. I have frequently observed this kind of problem in engineering. On the larger issues, the problem is even more pronounced, making it almost impossible for the "system" to decide what are the root problems it produces and what are merely derivative symptoms.

To what extent do engineering methods and approaches feed the system?

We asked two questions of a typical undergraduate engineering curriculum at the University of Toronto: "What do future engineers learn about how technology influences human life, society and the biosphere" and "To what extent do they learn to utilize this knowledge to adjust design and decision making to achieve the desired results and to prevent or minimize undesired results?" The answer, obtained by means of an exhaustive quantitative study, was: almost nothing. We then explored whether engineers learn to do so when they enter a particular field of practice, by examining current methods and approaches using the same research instruments. Again we found they learn almost nothing.

Perhaps the following analogy sums up the situation: Engineers, as specialists, had little choice but to "drive" technology into the future by concentrating on the readings of the instruments on the dashboard and paying peripheral attention to looking out our professional windows to what we might be bumping into.

The problems are further illustrated by the difficulties encountered in the teaching of engineering design. Faculty members and students find themselves in a situation not unlike the one encountered by a team of specialists examining the Colombian hunger problem. Design is supposed to be the synthesis of everything the students are learning in both the technical core and the complementary studies components of the curriculum. Complementary studies, such as economics, sociology or political science, should help to contextualize how technology impacts these aspects of society.

But a trip to any university bookstore demonstrates that this objective is not being met. A search of the indexes at the back of textbooks in such disciplines as economics, sociology or political science for entries to science and technology identifies relatively few and mostly incidental references, and only rarely a chapter devoted to the influence of technology. Is it possible to describe the functioning of a modern economy, the fabric of our societies, the working of our political institutions and a great deal else with little or no reference to the transforming roles of science and technology? How many daily-life activities do not directly or indirectly depend on some technology? Is our urban habitat not a "product" of our many technologies?

At the same time, examine a number of engineering texts for entries in their indexes referring to people, communities, societies, ecosystems or the biosphere, and we encounter the mirror image problem. The "intellectual worlds" of these disciplines are full of technology and little else, in contrast to those of the social sciences that are full of everything else and little or no technology. Surely this is a formidable obstacle to engineering synthesis and design.

This diagnosis immediately suggests the treatment lies in engineering education. The complementary studies component must examine how technology fits into everything else, and the technical core must apply this knowledge to ensure that the job is done in the best possible way, while at the same time preventing or greatly minimizing harmful effects.

In other words, future engineers would learn to design and make decisions in a manner that achieves the best possible ratio of desired to undesired effects. In this way, they could decisively contribute to remedying the deep structural economic problems faced by the industrially advanced world.

Pursuing these studies of undergraduate engineering education and state-of -the-art methods and approaches in various areas of application led to the invention of "preventive engineering". This approach has emerged out of 15 years of research at the Centre of Technology and Social Development at the University of Toronto, and was recently recognized by the Canada Foundation for Innovation as one of 33 significant contributions made by Canadians.

A first-year course was developed that introduced students to the theory and practice of preventive engineering, followed by two optional courses leading to a Certificate in Preventive Engineering and Social Development. This is a modest beginning, but it does demonstrate that the limitations resulting from high levels of specialization can, to a considerable degree, be overcome. In fact, we are so confident that a full-blown strategy for restructuring undergraduate engineering education is possible that we submitted a research proposal for doing so to the "Women Into Engineering" (WIE) project, which has now been accepted. (The WIE project comprises a partnership of the Ontario government, academe and PEO. For more see www.peo.on.ca/events/WEReports2001.doc.)

Since we expect to complete the documentation of preventive engineering in the next year, it will soon be possible to develop a knowledge transfer strategy to other universities, corporations and governments by means of professional development initiatives.

In the meantime, the ratio of desired to undesired effects of technological and economic growth is mounting; and sooner or later politicians and the general public will draw the conclusions from this evidence. I am proposing that as a profession we do not wait that long. We must proactively address this challenge. Many of our deep structural economic problems, spiraling health costs, social issues, and the environmental crisis could be alleviated; and contrary to conventional wisdom, there is growing evidence that this can actually improve the competitiveness of corporations and economies.

A first-year course was developed that introduced students to the theory and practice of preventive engineering...

By restructuring undergraduate engineering education, we can make engineers as socially and environmentally literate as they are technically competent. We know enough to get the ball rolling, and already have the quantitative instruments to permit the Canadian Engineering Accreditation Board to set and monitor standards for increasing the compatibility of technology with its contexts. ◈

Willem H. Vanderburg, PhD, P. Eng., is the founding director of the Centre for Technology and Social Development, Faculty of Applied Science and Engineering, at the University of Toronto.