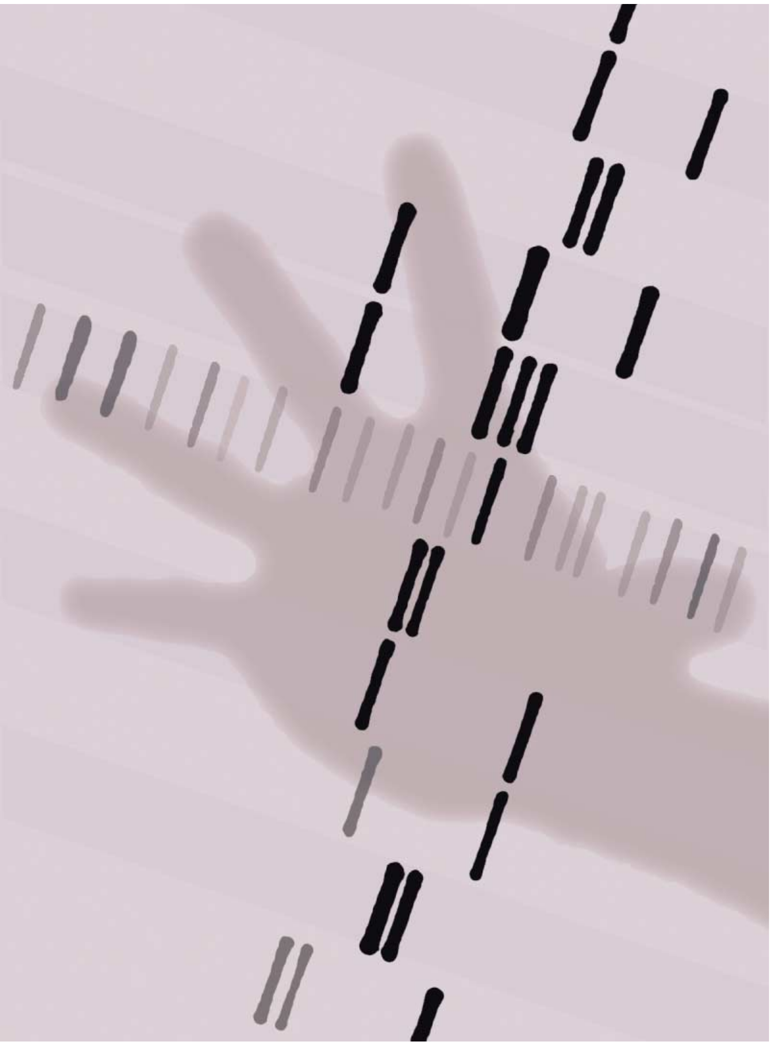
SCANNING



THE EMERGING AREAS

The accelerating emergence of such specialties as nanoengineering and tissue engineering poses challenges to the engineering profession. Are they really engineering? Or are they trading on the value of the term "engineering?" And for those that have an engineering component, where do engineers fit within the practice, and what are the required education, training and standards for licensing in the public interest?

Sometime soon, professional engineers practising within such traditional disciplines as mechanical, electrical or civil engineering will find themselves working alongside people holding degrees in cognitive engineering, tissue engineering, and nanoengineering–and the profession needs to be ready, say its regulators.

Such vigilance is based on the profession's past experience with the rapid rise of software engineering, the demand for which few in the early 1980s could have predicted would be so great only 10 years later. This demand resulted in a proliferation of schools offering software engineering programs that were "engineering" in name only. "The high technology industry expanded quickly, and a lot of people were calling themselves software engineers, but they often were really computer scientists," says Karen Martinson, P.Eng., manager, research and evaluation, Canadian Council of Professional Engineers (CCPE), the federation of the provincial/territorial engineering licensing bodies, including Professional Engineers Ontario (PEO). "The term 'engineer' does get misused, and the more the word 'engineer' gets misused, the more watered down it becomes."

And the more difficult it is for anyone outside a given field to know who is and who isn't a licensed professional engineer, or where the oversight of professional engineers is required to protect the public. CCPE's new research committee is tasked with scanning the horizon and looking to the future. The committee is on the lookout for the moment when the discoveries of science in a particular area first begin to be applied consistently to design and analyze processes, products and services for the benefit of society–the threshold crossed by each new engineering discipline.

"There has been many new kinds of engineering that have started in the last few years," Martinson notes. "We research those areas, and if an area looks as if it has potential to employ engineers or impact the engineering profession, we issue a research paper. Part of the reason that we monitor emerging fields is to ensure that the engineering profession is prepared, because our provincial associations are responsible for regulating the practice of engineering. Another reason is so we can describe the new fields to others."

by Perry Greenbaum

Putting software to the test

PEO began looking seriously at the proliferation of new practice areas in 1997 when a Task Group on Emerging Engineering and Multidisciplinary Groups issued a final report that recommended that PEO establish a standing committee on emerging and non-traditional engineering fields where regulatory issues might arise. The committee would research and define issues in targeted areas to better understand the area of practice, regulatory needs and potential solutions, and focus as its first priority on "information engineering." The report also called on PEO to "define a framework for, and the process of, licensure of engineers in newly emerging fields."

In March 1998, these recommendations were translated into the appointment of the Engineering Disciplines Task Group (EDTG), with a mandate to identify and make recommendations to PEO Council on professional practice and admissions issues in software engineering, and to develop a procedure for recognizing new specialities within engineering.

As the task group saw it, PEO's difficulty in licensing and regulating new areas of engineering practice stemmed from these areas having tended to evolve before any established academic curricula. Consequently, practitioners in the new areas were usually self-taught, and engineering graduates from established disciplines working within them were practising in fields other than the ones for which they were formally educated. Sometimes, degree holders in the new areas of practice would be those who were graduates of non-accredited programs.

In these circumstances, PEO had difficulty licensing individuals according to its traditional process, which involves ensuring that they have adequate academic qualifications, pass the professional practice exam, and meet PEO's other licensing criteria (like good character), and verifying that they have engineering work experience that is consistent with their academic backgrounds.

As a solution, the EDTG developed a licensing process for individuals practising in emerging areas that is consistent with PEO's traditional licensing process, and tested it by licensing software engineering practitioners, beginning in 1999 (see sidebar for a description of the process).

Nowadays, software engineering can no longer be considered an emerging area, with seven Canadian undergraduate engineering programs having been accredited by the Canadian Engineering Accreditation Board as providing the required academic preparation for licensing. Five of them–at Carleton, Lakehead and McMaster universities and the universities of Ottawa and Western Ontario–are in Ontario.

Working together

Meanwhile, to test its process further, the EDTG struck a Bioengineering Subgroup to define bioengineering for licensing purposes. Subgroup membership comprised both scientists and engineers. "We found their participation very helpful," says Max Perera, P.Eng., a former PEO Councillor, member and initiator of the subgroup. "The scientists made very important points."

Released in November 2001 and approved by PEO Council in February 2002, coincident with Council approval of the EDTG's documented process for identifying and licensing emerging areas, the *Final Report of the Bioengineering Subgroup of the Engineering Disciplines Task Force (EDTG)* established bioengineering as the second emerging area to become a recognized discipline. In its report, the subgroup defined core bodies of knowledge for bioengineering, biochemical/food engineering, biomedical engineering and bioresource engineering, and identified the associated areas of practice. By the end of 2002, PEO had licensed its first seven bioengineers.

Michael Price, P.Eng., PEO deputy registrar, licensing and registration, says that in keeping with Council's approval of the EDTG recommendation that PEO seek actively to identify new engineering disciplines, “we are keeping abreast of what's happening in the workplace, and also working closely with the CCPE, which is an important relationship, because the national body looks at a broader picture–what is happening in all the Canadian provinces.”

What Price and others are finding out is that, consistent with the findings of the EDTG, the emerging fields are not simply sub-disciplines of traditional engineering programs, but rather new entities that may combine aspects of several traditional engineering disciplines with pure science or other professional studies. And just as the EDTG described, what is generally lacking in such emerging fields as tissue engineering or cognitive engineering are the accredited programs of study that ensure regulators that graduates are academically prepared for licensing.

Growth areas

Two areas that seem set to emerge and are thus at the research paper stage of CCPE's monitoring process are tissue engineering and nanoengineering.

In Nanotechnologies–*A New Area of Growth for Engineering?, which CCPE* researched in August, it is predicted that nanotechnology will create more than 500,000 jobs in the United States in the next 10 years. “Canada is also forecasting vast job-creation prospects in the area of nanotechnologies over the next decade,” the report states. Chris Morris, in industry development, nanotechnology, for Industry Canada's manufacturing technologies directorate, says “Universities are addressing the expected need for nanoengineers, but it's a future profession that's just emerging.”

Nevertheless, the University of Waterloo is expected to graduate 100 nanoengineers by 2009, and the University of Toronto has an undergraduate option in nanoengineering. In 10 years, there may well be hundreds of nanoengineering graduates working in Canada, many in Ontario, driven by the convergence of three factors:

Going boldly: identifying and licensing emerging areas

Approved formally by PEO Council in February 2002, but used by PEO to license software engineers since late 1999 and more recently bioengineers, the process developed by PEO's Engineering Disciplines Task Group to identify new areas of practice and license practitioners in them comprises five phases:

1. Discovery–recognizing a new practice area and recommending a standing committee to assist in monitoring it;
2. Identification–identifying the necessary knowledge for competent practice in the new area, i.e. its body of knowledge;
3. Definition–using the body of knowledge to define the required and optional areas of study that would comprise an academic program in the new area that would fulfil the academic requirements for licensing;
4. Evaluation–reviewing the experience and education of current practitioners in the new area to determine if they have provided practitioners the required body of knowledge for licensing;
5. Legislation–identifying the areas within the new area where an exclusive scope of practice for licensed P.Engs is necessary to protect the public interest and working with government to develop demand-side legislation covering those areas.

- development of new instruments, such as scanning tunnelling microscopes, which give researchers the means to track and manipulate things as small as a single atom;
- recent advances in information technology that give scientists the ability to construct computer-based models of things that are too small to see directly; and
- advances in measurement sciences.

Such advances, although holding great promise for society, pose a challenge to licensing bodies like PEO. “We have to capture these developments before things evolve too far,” Price says. “We're trying hard to stay ahead of the curve, but things develop a lot faster today than in the past.”

Certainly, many Canadian universities, from Dalhousie University in the east to the University of British Columbia in the west, have also been trying to ride the same wave by conducting research in nanoscience. And the first academic institution in the world to be credited withestablishing a nanoengineering option at the undergraduate level is the University of Toronto (see sidebar, “Thinking small in a big way: nanotechnology”).

Doug Perovic, PhD, P.Eng., chair of both U of T's department of materials science and engineering and the nanoengineering program, defines nanotechnology as “developing a new material property or behaviour , which would not exist in the same material at a larger scale.” His program is fed by seven departments: chemistry, material sciences, electrical and computer engineering, biomedical engineering, mechanical and industrial engineering, chemical engineering, and applied chemistry. Professors from each department give courses, including new courses developed for this option. “It has been a good success story of bringing together profs from a huge university, which is hard to do,” he says.

As to the likely areas of practice for nanoengineers, Perovic agrees with many who point out that the first major sector where nanoengineers will generate new technologies is in the biomedical field.

Engineers link with medicine

The second of the soon-to-emerge areas is tissue engineering. In a paper prepared for CCPE, *Tissue Engineering-A Professional Engineering Perspective* (August 2002), lead author Michael S. Kallos, PhD, P.Eng., faculty of engineering, University of Alberta, writes

> “So much is happening today worldwide with so many fields of science interacting with engineering...”
>
> Max Perera, P.Eng.

Thinking small in a big way: nanotechnology

When the University of Toronto launched its nanoengineering program in September 2001, it was not only the first of its kind in Canada, but the first in the world. The program has been designed to give students an understanding of the architecture of atoms and molecules, and how to assemble them to perform a specific function.

The first cohort of 13 graduated in June 2003 with a Bachelor of Applied Science in Engineering Science with a specialization in nanoengineering. “Most have continued on to do graduate work, and a few are working in companies,” says Doug Perovic, PhD, P.Eng., chair of the department of materials science and engineering and of the nanoengineering program. “They are working in companies where they bring in expertise on the nano side of things, but there aren’t too many nano companies in Canada yet working on nanotechnology.”

Nanotechnology is concerned with phenomena originating from nanometre-scale (10^{-9} metre) structures of matter, corresponding to the atomic or molecular scale. As Perovic sees it: “Nanoengineering is really an extension of what we have been doing for the last 100 years. The work of a nanoengineer is similar to that of a traditional engineer, except it is done at the nanoscopic level.”

For example, a nanoengineer might organize atoms and molecules into a particular structure, which results in a material that exhibits different electro-chemical properties at the microscopic level than at the macro level. “A student working at Stelco, for example, might design a nanocrystalline steel,” Perovic says, “and test the benefits of that against the micro-level steels that we have been using for decades.”

that tissue engineering “has been hailed as one of the hottest jobs of the 21st century.” Broadly defined as the development and manipulation of laboratory-grown molecules, cells, tissues and organs, tissue engineering “aims to assist the body in actually regenerating lost function, rather than masking symptoms, as many therapies do today.”

“We don’t have an accredited tissue engineering program yet,” CCPE’s Martinson says. “But that might happen in the future.”

Licensing and regulating tissue engineering poses some tricky challenges, Martinson points out, because it represents the merging of medicine and engineering. “To effectively license someone working as a tissue engineer, the engineering profession needs to understand the work involved and be able to effectively evaluate work experience,” she points out. There are people out there, many of them working in research institutions and universities, but they are currently few in number.

Still, as new fields progress, more reviewers will become available.

For now, Martinson says, the profession can be proactive. “If we are educating the public about the engineering component of these new fields, then at least we are ahead of the game,” she says.

And it’s still an open question whether some of the emerging areas aren’t so far removed from engineering as the profession knows it that they have no place within it. “But we’ve got to be open,” Perera argues. “Once the new fields fully evolve, we can identify those that should come under professional engineering licensure.” And looking to the future, the profession may even have “to revamp our understanding and definition of professional engineering,” he says.

The engineering mind tends to like clear delineated boundaries: this is engineering and that is medicine. And, until recently, these boundaries have served the public interest well. “But now we need to veer from that point of view,” Perera says. “So much is happening today worldwide with so many fields of science interacting with engineering, that if we stay with pure engineering, we won’t be able to adequately serve the public interest.”

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The best of both worlds: mechatronics

The University of Waterloo’s (UW) mechatronics program, launched in September 2003, has 106 students.

Although overseen by the mechanical engineering department, it also emphasizes electrical engineering knowledge. “It is a mixture of what mechanical engineers take, and what electrical engineers take,” says Jan Paul Huissoon, PhD, P.Eng., Waterloo’s director of mechatronics engineering. “Eleven courses from the electrical and computer engineering and from the systems design engineering programs are integrated into the curriculum.”

Mechatronics attempts to reflect the reality of living in a Digital Age, Huissoon says: “Mechanical engineers tend to have an aversion to things electrical, and electrical engineers to mechanical design. You can’t design an electro-mechanical system without having enough knowledge of both.”

If interest is an accurate measure of success, the program is already on its way. There were 10 applicants per space, or as Huissoon puts it, “the highest in all of engineering at UW.”

Students will graduate with a degree in mechatronics engineering. The Canadian Engineering Accreditation Board will review the program for accreditation after the first cohort graduates in 2008.