V I E W P O I N T

Time to separate engineering and applied science?

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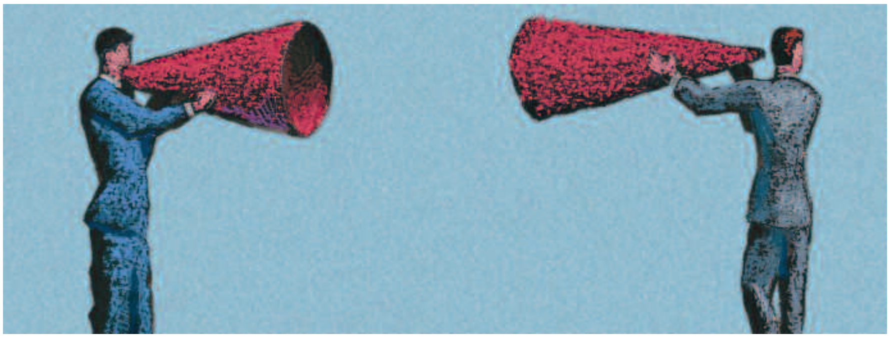

Developing separate undergraduate and graduate programs in engineering and applied science could have a positive impact on the *practice* of engineering. As well, there may be significant opportunities for the profession and society with the development of more doctoral-level engineering programs. Here is one educator's view.

The Canadian Engineering Accreditation Board, a committee of the Canadian Council of Professional Engineers, uses the same criteria to regulate programs in both engineering and applied science. Though managed separately by the provinces, graduate programs are treated the same way. I believe this is a problematic situation, and that it's time to separate engineering programs from applied science programs.

Strained system

Some people are convinced that we need deeper education in mathematics and science at the undergraduate level because these are the essentials of engineering. Significant human resources are devoted to the analysis of the physical behaviour of products, without which products cannot be brought to market reliably. Some baccalaureate engineers will also pursue graduate work that will require superior knowledge of math and science.

There are other people who are convinced that there is a greater need for undergraduate training in design, manufacturing, project management and business. Most engineers in industry will not need to conduct *scientific* work. They will instead *practise engineering*, which is far broader than just math and science. Industry has made its desires known on this count: We are not educating our engineers properly in the *practice* of engineering[1, 2, 3].

We cannot increase both the scientific and practical aspects. The typical university "engineering" program is already overflowing. Moving to five-year programs only promotes adding even more advanced material to the curriculum–not to mention the extra years' debt incurred by students–without any expectation that students will be better for it.

The "siloing" of programs by department also severely limits the opportunity to train students in multi-disciplinary design activities, such as concurrent engineering. While not necessarily needed in purely scientific/analytic work, it is pretty much fundamental to the practice of modern engineering.

Developers of conventional undergraduate curricula originally assumed that an "apprenticeship" would follow graduation. Apprenticeship became extinct years ago, but the curriculum has remained largely unchanged. Changes have been made sporadically, locally, and typically in response to other issues (e.g. funding).

There are problems at the graduate level, too. For example, the master of engineering degree is often regarded as a "master's lite" for students unable to meet the requirements of a master of applied science. In Ryerson University's MEng program in mechanical engineering, one takes eight credits of coursework and two credits of "project," whereas MASc students take five credits of coursework and five credits of "thesis." Though reasonable at first glance, it really isn't. Graduate courses are intense, theoretical, and usually oriented towards the research interests of the instructor. They are rarely of use to practising engineers. (Visit the online graduate calendars of any Canadian university to see this for yourselves.) This is a problem because the MEng–supposedly the practical degree–requires more *theoretical* coursework than the academically oriented MASc. Does this make sense?

Finally, while a PhD has become the gold standard for academics, it is nearly useless in industry.

There is a complete lack in Canada of any capacity to train engineers in practical matters to a level of excellence equivalent to the PhD.

Relieving the strain

One solution to all of these issues is to separate engineering education from applied science education at both undergraduate and graduate levels. This leads to two equal and parallel streams.

The applied science stream would be largely based on existing accreditation requirements, with possibly less emphasis on topics like design and manufacturing. The essence of the proposed applied science

Engineering

BEng
- basic design and manufacture practice
- teamwork and creativity
- impact of business, marketing, etc.

MEng
- project-management training
- advanced design and manufacturing methodological expertise
- training in business, marketing, etc.

DEng
- innovation, societal, governmental, and corporate leadership in technology and product development

Applied Science

BASc
- entry-level analysis of engineered products and manufacturing systems
- deep, quantitative understanding of fundamentals of applied science

MASc
- deep analysis and guided research
- writing academic publications
- introduction to teaching (assistantship)

PhD
- teaching, research, and grantsmanship excellence

stream would be to prepare graduates to undertake rigorous scientific work in engineering analysis and research. The most significant change would be at the PhD level, where students would receive training in teaching and "grantsmanship"–topics typically ignored in current doctoral programs.

The engineering stream would embody the biggest changes. The BEng degree should embody so-called just-in-time (JIT) teaching of science and math, to ensure that whatever knowledge is taught is directly connected to some aspect of engineering practice. At the moment, most undergraduate programs do not implement JIT teaching, with the result that science and math taught in the junior years must be repeated at senior levels–wasting even more precious time.

All BEng degrees should end with a significant, team-based, design-oriented, industry-driven capstone. Many schools are now implementing capstones, but they are encountering difficulty in fitting them into curricula already jammed full of science and math. In the proposed solution, there would be ample time to allow students to fully develop designs and even prototype them.

The MEng degree would also have to be overhauled. New courses would have to be developed or provided as service courses from other faculties (e.g. business, project management). Heavily theoretical courses must be limited in the MEng stream because most MEng graduates going into industry will undertake project-management or product-development roles. They would be expected to take advantage of applied scientists to carry out detailed analytic tasks. The MEng degree should culminate in a capstone similar to the BEng, but with both greater depth and breadth expected of the student.

The DEng (doctorate of engineering) degree would have to be created from scratch.

There are no DEng programs in Canada; there are some in the U.S., Australia, the U.K., and other European countries. The DEng prepares individuals to enter the executive level of policy-making, product development, and industry; they will be international leaders in innovation.

This is not yet a saturated market and could help attract outstanding individuals to Canada. The DEng would also open a new revenue stream for universities by providing a much-needed service to holders of MEng degrees (who, by definition, cannot enter PhD programs).

By separating engineering and applied science, we could relieve the pressure on both programs to *necessarily* produce "renaissance engineers," able to be both experts in theory and in practice. Individual schools can then determine their own best mix of theory and practice; the new system would only set minimum standards. At the same time, we could prepare students better by focusing more on the field itself (applied science or engineering) rather than the somewhat forced amalgam of the two that we have.

Competition would be lessened in the new scheme as well. Ryerson University (which offers BEng degrees) would no longer feel itself to be in competition with the University of Toronto (the archetypal BASc system). Indeed, the environment for collaboration would be strengthened. Basic engineering research done at, say, the University of Toronto, could then be developed in practicable technologies at, say, Ryerson. Engineering schools and applied science schools would no longer necessarily have to pursue funding from the same set of agencies and funding programs.

It would take an immense, though not necessarily expensive, effort to implement a plan like this. It would call for all stakeholders, including the deans of Canadian engineering faculties, the CEAB, the provincial ministers of education, the Natural Sciences and Engineering Research Council, and all the pertinent provincial funding agencies to buy into the plan, at least in principle. It would require a national undertaking and the leadership of a core group of individuals willing to dedicate themselves to see this change happen.

The benefits are many, the costs relatively few. And I believe the Canadian engineering educational system would win, and so too would all of us.

References

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3. Canadian Manufacturers and Exporters, *Manufacturing Challenges in Canada*, 2004.

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