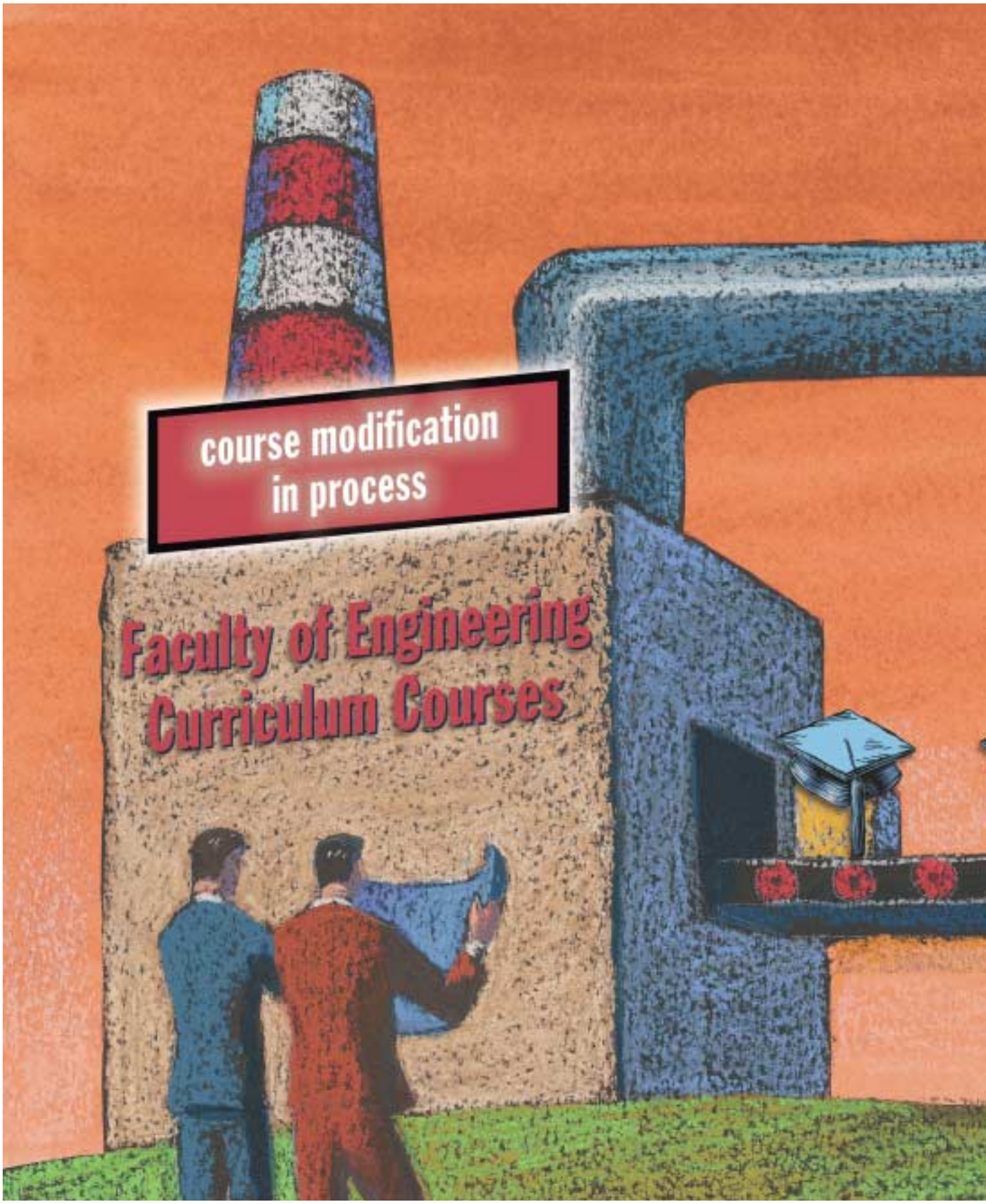

course modification
in process
Faculty of Engineering
Curriculum Courses

ENGINEERING EDUCATION FOR THE 21st CENTURY

Changing curriculum at the University of Toronto

There's a long-standing tradition of teaching technical excellence in engineering education. But today's graduates require a broader range of expertise to meet the needs of a complex marketplace. The University of Toronto has developed a new curriculum framework to position its engineering graduates as both well-rounded and technically competent.

By William R. Cluett, PhD, P.Eng.

In May 2000, the faculty of applied science and engineering at the University of Toronto established a Task Force on Curriculum Change (TFOCC) with a clear mandate to develop a new framework for undergraduate engineering education. The framework was to result in a curriculum that produces graduates who can meet the professional and societal demands of engineers through the 21st century.

The faculty recognized that there is a need to go beyond developing technical excellence in engineering education. Students must be exposed to history so that they can learn from their past; they must be exposed to human sciences so that they have a better understanding of the relationship between people and technology; and they need to be exposed to social sciences so that they know what impact they can, and should, have on society.

For our profession to lead society in developing solutions to some of its most pressing problems, the faculty realized that graduates require a different set of characteristics than in the past.

Professors Richard Bonert, P.Eng., Kim Vicente, P.Eng., and Kim Woodhouse, P.Eng., served as TFOCC members. They followed five guidelines to develop the new framework:

- expansion of the humanities and social sciences with the opportunity for both depth and breadth;
- vertical integration of engineering design throughout the curriculum, including first year;
- greater curricular flexibility to provide students with a wide choice, in particular in non-technical subjects;
- increased emphasis on the development of professional skills; and
- curriculum development within the institutional context of a large, publicly funded Canadian research university.

A four-year degree with an average of five courses a term was also assumed.

One of the most interesting aspects of the new framework is the introduction of first-year students to engineering design, synthesis and communications. Traditionally, design is viewed as a capstone element of undergraduate programs, giving students near the end of their education an opportunity to integrate what they have learned... to develop new products and processes.

Integrated learning

The TFOCC officially proposed a new curriculum framework in January 2001. The following May, the faculty agreed that its undergraduate curricula should evolve along these general directions:

- more flexibility among technical and non-technical courses;
- more opportunities for integrated learning using synthesis/design courses as a vehicle; and
- more opportunities for students to include a minor specialization to go with their engineering degree.

One of the most interesting aspects of the new framework is the introduction of first-year students to engineering design, synthesis and communications. Traditionally, design is viewed as a capstone element of undergraduate programs, giving students near the end of their education an opportunity to integrate what they have learned in mathematics, basic sciences, engineering sciences and complementary studies to develop new products and processes.

However, there has been a well-documented paradigm shift over the past decade or so in engineering education.[1, 2] One of the central tenets of new engineering curricula is an introductory course that provides students with a framework for engineering practice. They begin to learn aspects of systems engineering and design, along with communications, teamwork and other professional skills, and thereby gain some sense of the excitement of the engineering profession.

First-year framework

The faculty established a Working Group (WG) in January 2002 to develop such an introductory course for its own first-year students. The faculty felt it was in a strong position to develop something unique to engineering at the University of Toronto, drawing on its existing strengths in design, preventive engineering and social development, human factors, and language across the curriculum.

WG members Professors David Bagley, P.Eng., David Kuhn, P.Eng., Susan McCahan, Pas Pasupathy, P.Eng. and I, started by defining the student needs that were unmet by the current first-year program. Based on these student needs, the WG constructed a list of goals for the new course in terms of student accomplishments. This list was then reformulated into a set of learning objectives, including what students

need to be able to do to meet the expectations. Finally, the learning objectives were clustered into six modules to form the course outline.

Ramping up ESP

Engineering Strategies and Practice (ESP), the resulting course, has a clear emphasis on design and communication. The design component is used as a methodology to accomplish several of the learning objectives. It is a vehicle for understanding and practising problem solving and for developing communication skills.

In addition, design problems naturally require a holistic approach to problem solving that takes into account social, environmental, and human factors as design constraints. They offer students a larger view of the scope of engineering, which will gradually be filled in by the subdisciplines of engineering as they go through their undergraduate program. The course is viewed as foundational; the objective is to start encouraging students right away in first year to synthesize and integrate their knowledge in the broader engineering context.

ESP is a two-course sequence–ESP I in the fall term and ESP II in the winter term. It will be offered on a pilot basis for 100 students starting in September 2003 with the plan to ramp up quickly to accommodate all first-year students.

ESP I offers a combination of lectures and tutorials. The design process is introduced and hands-on projects give students a chance to grapple with the challenges of engineering design. Writing and reading, as engineering activities, are introduced. Students will also learn how to identify social, human, and environmental factors as frontline design considerations.

In the second half of the first term, students will have the opportunity to select a technology-related topical seminar. In small groups, the technical, social, and political issues associated with the chosen topic will be debated and each student will make a presentation on one related aspect.

ESP II focuses on tackling a design project from beginning to end. Students will learn the basics of project management, how to approach a complex problem and break it down into solvable parts, and how to acquire and use information in the design process.

In this term, there are fewer lectures and more tutorial time. The students will team up to work on a major design project. Working with a client, they will go through a complete design process to develop a workable solution to meet the client's need. The end result will be a portfolio of written and graphical work and an oral presentation.

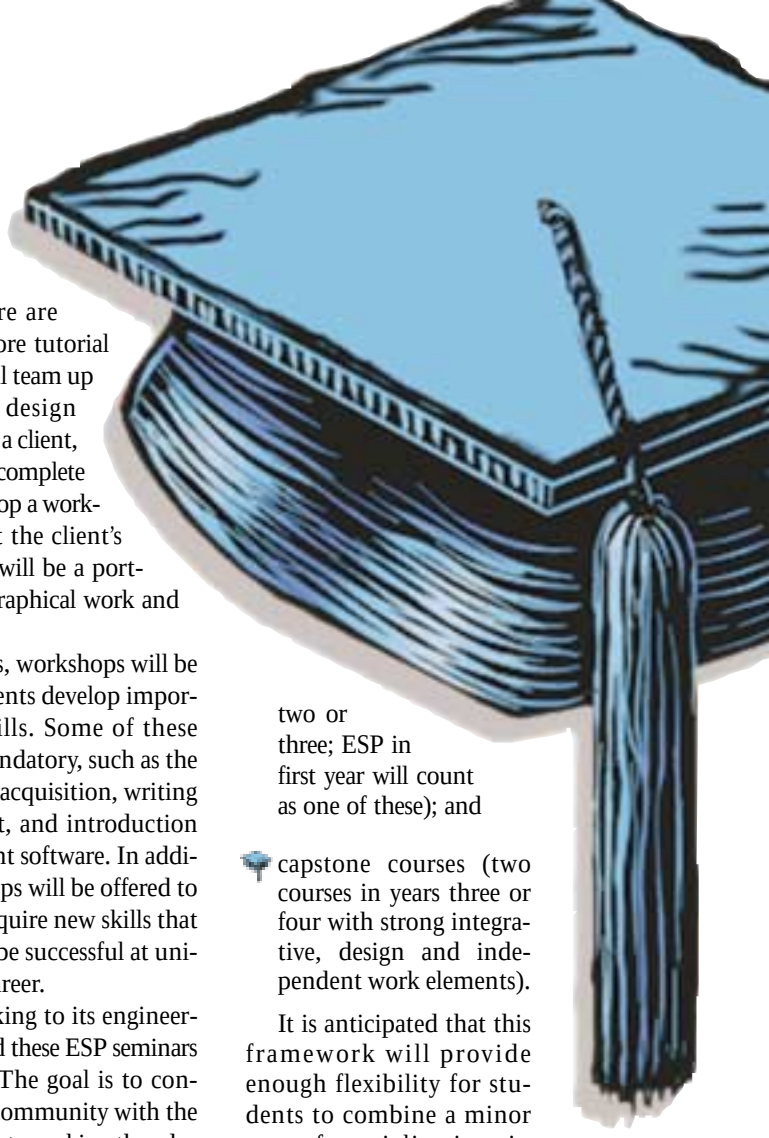
During both terms, workshops will be available to help students develop important professional skills. Some of these workshops will be mandatory, such as the basics of information acquisition, writing an engineering report, and introduction to project management software. In addition, elective workshops will be offered to improve upon and acquire new skills that students will need to be successful at university and in their career.

The faculty is looking to its engineering alumni to help lead these ESP seminars and design projects. The goal is to connect the engineering community with the faculty's current students, making the educational experience that much more meaningful and relevant.

Operation curriculum renewal

ESP is only the first step in the curriculum renewal process. This spring, the faculty adopted a set of minimum program requirements as guidelines for on-going curriculum change across all of its undergraduate programs:

- complementary studies electives (four courses, including at least two humanities and social sciences electives);
- engineering economics (one course);
- technical electives (four courses);
- alternative electives (two courses; complementary studies, technical or free elective as determined by program needs);
- design courses (three courses with substantial design content in years one, two or three; ESP in first year will count as one of these); and
- capstone courses (two courses in years three or four with strong integrative, design and independent work elements).



It is anticipated that this framework will provide enough flexibility for students to combine a minor area of specialization, in music for example, with their engineering degree.

Clearly, the faculty's vision is to move toward a more flexible curriculum that exposes students to a broad set of topics without sacrificing technical excellence. The faculty firmly believes that well-rounded and technically competent engineering graduates will be in the best position to serve society.

1. Fromm, E. "The Changing Engineering Educational Paradigm," *Journal of Engineering Education*, vol. 92, 2003, pp. 113-121.

2. Splitt, F.G."The Challenge to Change: On Realizing the New Paradigm for Engineering Education", *Journal of Engineering Education*, vol. 92, 2003, pp. 181-187.

William R. Cluett, PhD, P.Eng., is completing his term as the vice-dean (undergraduate) and chair of first year in the faculty of applied science and engineering at the University of Toronto. He can be contacted by email at cluett@ecf.utoronto.ca.