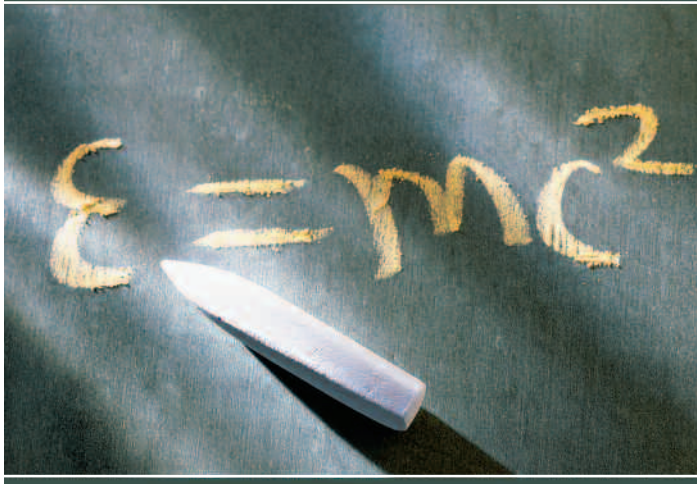
HEAD OF THE CLASS

Innovation in engineering education gets top marks

An engineering education has come a long way from numbers and equations on a blackboard. Today's innovative programs incorporate real-world project experience, industry partners, cross-disciplines and entrepreneurship to develop graduates for a competitive global marketplace. Here's a look at five unique programs–four in Ontario, one in Alberta–that will move the profession forward.



by Karen Hawthorne

Jeremy Steffler, P.Eng., worked for an environmental consulting firm before joining the engineering faculty at the University of Waterloo, where he had received his bachelor's and master's degrees. His engineering firm hired about five co-op students from Waterloo during the time Steffler was on staff, and hearing the comments from coworkers involved in the hiring process gave him insight into the students' strengths and weaknesses.

"There were excellent technical students who knew the material and were very bright individuals," he says, "but when they had a report or presentation to do, they used an academic approach that wasn't geared toward clients." He says the same can be true of new hires right out of school who aren't ready to go straight into the field or interact with clients. "After a couple of months, no problem, they pick up the skills," Steffler adds.

But in a competitive marketplace where staff members have a lot of responsibility and multi-faceted jobs, there is little time for acclimatizing new hires to corporate culture and to the high demands of business. Employers are looking for people who can step right in and perform from day one, he says.

Now, Steffler is assistant director and the hands-on coordinator for the Professional Development for Engineering Students (PDEng) program at Waterloo, which focuses on professionalism in the workplace and developing communication, leadership and problem-solving.

Waterloo has a long history of innovation in education. It was the first Canadian university to launch co-op work terms as part of the engineering undergraduate curriculum in the late 1950s. More recently, the university and industry partners recognized a need to develop and assess soft skills and professionalism during those work placements. To meet this need, the University of Waterloo Faculty of Engineering struck a steering committee in September 2003 to develop the PDEng program for start-up in September 2004. Members include Steffler, and faculty and student representatives.

"As soon as I heard about the program, I was sold on it. It's about understanding engineering as a profession and what that means," says Steffler. "There are P.Engs who are taking these same kinds of courses for professional development."

The PDEng program has been billed as a "comprehensive and practical introduction to the professional world"–why and how ethics come into play and what professional conduct is all about.

The program comprises five online courses, each to be completed during the undergraduate student's work term, and all five must be completed before graduation.

About 30 hours are required over the average 16-week work term–about an hour and a half each week–with 24-hour access to the online program, and grading and guidance provided by a senior engineering student mentor throughout. After reading the material for each lesson, students are graded on a variety of tests: quizzes, short-answer questions, paragraph-length questions and essay-style questions. They must maintain a 75 per cent minimum grade on all activities, but have the opportunity to re-do assignments to secure that percentage.

The main themes addressed in the five skills development courses include:

- becoming an effective employee;
- critical analysis in the workplace;
- professionalism and ethical decision-making;
- becoming a leader/project manager; and
- integrating professional skills for a global workplace.

Students relate work-term experiences to the PDEng course assignments. They identify three potential topics for their first work report, explain why the topics were chosen, and then contact their mentor for guidance in writing the report, if needed. They are asked to reflect on how work is managed and carried out on their work term, and how decisions are made. Another assignment involves students brainstorming potential work term report topics and identifying the analytical approaches that would need to be applied to prepare their reports.

"Typically, in business, it's a little dangerous to have only one solution to your client's problem," explains Carolyn MacGregor, program director and a professor of systems design engineering. "We want to give students a better understanding and context to what's expected in the workplace. I'd like to think that we have set the bar high, and continue to set it higher. We want to provide a good learning experience for our students, which means faculty being involved a bit more in the work term."

Reports from the Canadian Council of Professional Engineers have identified soft skills as an area needing improvement for engineering students, she says. What the PDEng program does is provide the university with a means to evaluate the softer skills that give students a broader set of competencies, such as strong communications, strong critical analysis and an understanding of the "human component" in the working world.

"You can't become a good manager of others if you can only function and do things yourself," MacGregor says. The results of the program, with permission of the students, will become part of the research MacGregor is heading up concerning soft skills and how they are learned. The PDEng program will continue to be refined.

"There is more to becoming a professional than just getting letters after your name. Being able to move toward being responsible, accountable engineers–that's why we're here," MacGregor notes.

The mentorship of first-year students by senior students is another positive aspect of the program, she says: "You have all these changes going on, so these really become life-learning skills and the mentors are like a lifeline. Being on the front lines, I see the difference in these students after a month. During the first course (Professional Engineering and You: Being an Effective Employee) students make insightful comments about what soft skills are and what their own weaknesses may be."

While the program aims to help students understand the profession and become more valuable employees, directors hope it will also bring professional engineers into mentoring roles, with new graduates who have mentored students in the PDEng program staying connected to the program or the younger students who they have helped. Professional engineers with no previous connection to the program are also encouraged to get involved, Steffler says.

"The program has such potential to influence how students view the profession, and relaying the importance of the licensing required to join the profession," says Steffler. "I think there are plenty of professionals who want to give back."

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Carolyn MacGregor

Engineering in the global context at The University of Western Ontario

A new "green building" is in the works for the engineering faculty at The University of Western Ontario, with space for teaching, research and student activities. It's an environmentally friendly building, which is being designed by Western engineering students enrolled in a fourth-year engineering design course that incorporates students from all engineering disciplines. The school put the idea forward a year ago and industry partners and the Canada Green Building Council came on board to help support the project.

Engineering Dean Franco Berruti, P.Eng., calls the proposed new facility "a landmark of what can be done" in the future of engineering education when industry, government and academe partner. He sees the facility as a means to further research and development projects that will fuel innovation in Canada and advance technology in industry. "This is an example of the type of enrichment across disciplines that can happen," says Berruti of the team effort from the departments within the engineering school. "It's the most innovative project yet. It's a wonderful learning and research opportunity to build upon this infrastructure and we want the students to have a sense of ownership."

The University of Western Ontario, widely known for its Richard Ivey School of Business, is seeking to be known for something more with its Engineering Plus program. The "plus" represents a variety of educational enrichment options available to students that continues to evolve as needs are identified.

Berruti says the school's vision is to promote graduate education and research, thereby increasing the graduate student population. For engineering, the incentives to enroll at Western need to be loud and clear because of declining interest and high tuition costs. "Students from the GTA


Testing a water filtration system at the University of Calgary's


Waterloo's PDENG students learn "soft skills" like professionalism and ethics through online courses.


Professors Johnston and Caswell help a University of Calgary student with a "skatebot."


Racing the "skatebots" at Calgary's

tend to stay in the GTA and surrounding schools tend to suffer," says Berruti.

Western's strategy is to attract high-calibre students at the undergraduate level and promote engineering as the foundation and framework for various career options.

"These students will become the leaders, the entrepreneurs and the managers of engineers of the future," he explains. "We want our students to work in a more creative environment where we connect our undergraduates to graduate studies."

To do so, Western offers an accelerated master's program, where undergraduate students can begin paid summer research projects after their third year that count toward their master's degree; concurrent degrees to take advantage of Western's business and medical schools, for example; 12- to 16-month industry internships to develop in-depth workplace expertise and contacts; and a new first-year engineering design course where interdisciplinary teams tackle design projects and make use of application-based training.

"Students become self-directed learners," says Jan Shepherd-McKee, manager of undergraduate services and the school's artist-in-residence. "We give them open-ended assignments in the design course and they have to come up with solutions and defend them. Engineering is a deeply creative activity and we want people to explore it."

While the most popular concurrent degree is engineering and business, students can pursue law, medicine, music, visual arts and many other areas. "Our engineering students have a good basic knowledge set–a core of strict technical training–that they can build on. The common first-year program tells them what engineering is and where they can go with it," says Shepherd-McKee. She calls it a unique "liberal arts for engineers" program, because although the engineering school is mid-sized, the university itself is quite large, which promotes the intermingling of business, law and medicine with engineering. The school also attracts international students and offers international exchanges, again enhancing its diverse student culture.

It is this kind of access and program flexibility that students are responding to–especially women in what traditionally is a male-dominated field, she says.

As Shepherd-McKee sees it: "The key to the future of engineering education is that it enriches any career. Here, students have the flexibility to use it to fulfill their own goals and aspirations."

Opportunity knocks for students in central Ontario

Georgian College and the University of Windsor have teamed up to offer Windsor's renowned Bachelor of Applied Science in Mechanical Engineering, Automotive Option, in Barrie.

The program, which begins in fall of 2006, marks the first time an Ontario college and university have partnered to deliver an accredited engineering degree. Students in central Ontario, who would normally attend an out-of-town university for their engineering degree, can now earn that degree at Georgian College in Barrie and prepare to become licensed professional engineers upon completion of the required work experience.

With Honda and many parts manufacturing plants nearby, students will also have the option of applying for the co-op program within the degree, giving them hands-on industry experience.

"Now when we go to a manufacturer, we have technologist, technician *and* engineering graduates," says Bob Emptage, dean of engineering technology at Georgian College.

"The program reflects the emerging role of colleges," he says, "how they are broadening their offerings to the community and are not restricted to training and diploma-level education but partnering with universities to graduate future engineers with a practical focus."

The University of Windsor degree program is part of an expanding and select group of university and Georgian College programs within the college's Institute of University Partnerships and Advanced Studies. The college created the institute in February 2003 to bring a broad range of higher education opportunities, particularly degrees and degree-completion opportunities, to the Georgian catchment area. This region is the most populous in Ontario without a university.

The automotive degree program is a timely partnership, according to Emptage. In Ontario, about 30 per cent of the economy is tied to the export of manufacturing products; within the automotive sector, Ontario plants manufacture components and assemble vehicles. The research and development of new components and manufacturing processes is key to growing the automotive sector, says Emptage. Graduating future engineers who can fill these research and development and engineer-management roles is the main impetus for the automotive option.

The Ministry of Economic Development and Trade has identified specific sectors of the economy to receive its grant dollars. The automotive sector and education institutions that develop and staff this sector are major recipients of that funding.

"To stimulate economic activity in Ontario, the provincial government needs to invest to keep these jobs in Ontario, especially when it comes to product and process innovation," says Emptage. Funding to Georgian College has allowed for state-of-the-art, industry-standard design laboratories for students in engineering technology and mechanical engineering with the new degree program to work together on projects.


Olympic oval proves to be fun for all.


A creative, "liberal arts for engineers" program is stressed at The University of Western Ontario.


Converting a car from gasoline to ethanol at the University of Windsor's Automotive Learning Laboratory.


Photo: Ralph Buchal
Western promotes graduate education with its accelerated master's program.

The University of Windsor has a sound reputation for innovative programs and is enthusiastic about the mechanical engineering degree with the automotive option, given its location in the centre of the North American automotive industry, says Robert Gaspar, P.Eng., Windsor's acting associate dean of engineering, Georgian College.

"Windsor has three plants that manufacture engines in the west end alone, so there's opportunity here to give students co-op placements and employment opportunities," he says. As Canada's first automotive university, Windsor identified the automotive pinnacle as one of three areas on which to focus its educational efforts.

The school has worked collaboratively with DaimlerChrysler Canada for many years and established the University of Windsor/DaimlerChrysler Automotive Research and Development Centre in 1996. In 2002, General Motors joined with the university and the Natural Sciences and Engineering Research Council (NSERC) to establish an industrial research chair in tribology of lightweight materials at the university. Tribology involves the study and research of the friction, lubrication and wear aspects of specific machining processes, which plays a role in the design and manufacture of lightweight materials and components in vehicles to decrease fuel consumption. The university has also established a design innovation R&D centre with a major international truck manufacturer.

The joint use of the University of Windsor/DaimlerChrysler R&D Centre presents a unique partnership so that students, faculty and DaimlerChrysler employees have the opportunity to work in close proximity.

For the automotive engineering option to roll out next fall, specialized courses will be offered in vehicle systems design, internal combustion engines, alternative fuels, light metals casting technology and advanced mechanical design techniques.

The joint use of the University of Windsor/DaimlerChrysler R&D Centre presents a unique partnership so that students, faculty and DaimlerChrysler employees have the opportunity to work in close proximity. Currently, the school has 13 donated vehicles for students to take apart, study and learn how they were put together.

This automotive option will satisfy both the industrial demand of local manufacturers and assemblers and the interests of incoming engineering students, who may want to work in the automotive industry, says Gaspar. "It's combining practical, hands-on experience skills with high-level engineering design and analysis."

Budding entrepreneurs find support at McMaster University

Craig Thornton is developing a solar-powered wireless network that lets laptop or hand-held users log easily on to the Internet outdoors. He is one of five students piloting a new engineering entrepreneurship program at McMaster University. He hopes to make a device that's small enough to be attached to a lamppost, enabling a Wi-Fi network to work on a downtown street or park.

Another student is working on a project that uses radioisotope imaging to diagnose and treat disease.

"We're teaching students how to take an idea and make it marketable," says Professor Rafik Loutfy, director of the new Xerox Centre for Engineering Entrepreneurship and Innovation, which opened at the university last fall as part of the School for Engineering Practice. The ideas must have practical applications so that graduates are able to complete the program with a viable business venture.

"In Canada, there's a gap between inventing and commercialism," he says. Part of the difficulty is that inventors don't usually have the required business knowledge and contacts to turn their idea into a company. Loutfy had been involved in research for Xerox for 30 years before joining the McMaster faculty.

Xerox Canada and the Xerox Foundation have donated $1 million to McMaster to create the Xerox Centre for Engineering Entrepreneurship and Innovation. The centre is the focal point for a new Master of Engineering Entrepreneurship and Innovation degree program now in its pilot stage and ramping up to launch officially this fall.

To gain access to the 18-month program, students must demonstrate that they have a great idea and the drive to see it through. Some may come from companies who want to take advantage of the research centre support and expertise to finetune inventions and their applications.

"Many corporations are not providing sufficient resources to emergent technologies because of the risk involved," Loutfy explains. The program provides the support and low-risk opportunity to promote the kind of innovation that's needed for industry. "We're hoping to provide a new generation of engineers who are at ease with business and new technology," he says.

Students will take their business through four phases: market evaluation, technology and market development, business development, and startup. In addition to classroom work, the students will work with

professors, industry experts and business mentors from a field relevant to their project.

"The question is: How can we promote all this good research more aggressively and show its commercial value?" says Dean of Engineering Mo Elbestawi, P.Eng.

"We can't teach that entrepreneurial flair, but we can teach how it can be polished and provide the commercial know-how."

He says the program fills a demand for leading-edge practical research that can be taken to the marketplace: "It has to do with lifelong learning. There's a growing market for this program because former graduates who have been working for two or three years in industry want to get involved in research." Pursuing an MBA is one option for career development, he says, but the Master of Engineering Entrepreneurship and Innovation program combines the necessary business expertise with practical technical research and development.

There are no guarantees that every student's business will succeed, but the program aims to provide every student the tools and contacts to develop ideas, solicit funding, and take a product to market. Elbestawi sees the program as a necessary sign of the times–academe partnering with the private sector to promote research and development and create jobs in the Canadian economy.

The Xerox Centre for Engineering Entrepreneurship and Innovation will be housed in an expansive new building to be completed by 2008. This March, General Motors of Canada also caught the partnering bug and has committed to establishing two new automotive engineering centres at the university: the GM of Canada Centre for Engineering Design and the GM of Canada Centre for Corrosion Engineering Research, scheduled to open in 2006 and 2007, respectively. "Engineering design is at the core of innovation in the automotive and manufacturing sectors," says Elbestawi.

These two centres may also provide future resources for the masters of entrepreneurship program.

"Fail often, succeed sooner" at the University of Calgary

Students in the common first-year engineering design course at the University of Calgary aren't supposed to get top grades all the time. They're asked to find solutions to problems and test them to see if they work. If the solutions fail, they learn what went wrong and try, try again.

"Fail often, succeed sooner" is the motto for the course that allows all 600 students entering the faculty of engineering the opportunity to *be* "engineers," says Professor Clifton Johnston, P.Eng., one of the course coordinators. "It is not a course *about* engineering, but a course about *how to do* engineering," he says. "In true engineering design work there is no right or wrong answer."

Professors present students with real problems and ask them to use their skills and ingenuity to solve them. "A big company might get someone to design something, create a prototype and test it, and it may not work. It's a long and costly process," Johnston explains. In the design course, the approach is to fully understand the problem and continually test possible solutions.

If a client says, for example, "We need more fire hydrants," because there have been a lot of fires in this area, engineering students try to determine the cause of the increase in area fires and identify alternative solutions that may solve the problem more efficiently, he explains.

The idea is to graduate future engineers who don't sit in an office waiting to be told what to do, but are confident in their abilities and take initiative right away.

There are no textbooks for the course. Instead, four linked design labs and Blackboard, an interactive online source of course information, are the primary resources for students. The students also receive a log book in which they include sketches, notes and ideas–much like the log book a professional engineer might use on the job. The log book accounts for 20 per cent of the student's final grade.

The course was developed over several years and rolled out in fall 2002 to meet the requirements of the Canadian Engineering Accreditation Board (CEAB) that "every student must have real-world, team-oriented, open-ended design experience before graduation," and the university's undergraduate redesign to incorporate these requirements into the first-year curriculum.

Historically, engineering graduates gained credibility through managing technology, but now technology is so sophisticated that credibility is based on an engineer's ability to take initiative, solve problems creatively and communicate ideas both visually and orally, says Johnston.

Visual arts and communications exercises have also been incorporated into the full-year course, so that students may be in the lab creating a design system to coordinate pedestrian, bicycle and vehicle traffic in the downtown core for the City of Calgary, or they may be in a classroom sketching inanimate objects.

"Engineering is problem solving. Just like using sound and emotion to create music, you can't begin to learn until you pick up an instrument," says Professor Daryl Caswell, P.Eng., the course coordinator.

Many students would not have stayed in engineering if this course had not been developed because they wouldn't have had a chance to see what they can do with engineering and experience its creativity, according to Caswell. He says the challenge across North America is to keep creative students in the profession to foster design and innovation in the marketplace: "We're losing our design ability even though we're the guys who started the auto industry."

The engineering design course partners as much as possible with real-world clients who want to give students the opportunity to work on research and development with practical applications.

Last year, students worked on the design of crash protection for outdoor community skating ovals across Canada; designs varied from foam padding to pliable fences of canvas panels on springs and vented air bags. Another project was working with a Calgary biomedical engineering firm to develop designs for a mechanism to hold limbs in place during surgery. A third project involved helping a local chapter of Engineers Without Borders (EWB) design environmentally and culturally sensitive solutions for water and housing in a small village in India.

"Everybody wins," says Johnston. "Companies may get ideas from student projects and students have this real-world experience to talk about at a job interview."