4

Cross-disciplinary collaboration and experiential learning are integral to our innovative approach to engineering education. Through rich curricular and co-curricular opportunities, we enable our students to apply their strong technical abilities in context, as well as to develop competencies in leadership, project management, communication and entrepreneurship.

Students in all of our programs can customize their degrees and pursue their interests through 21 minors and certificates, including our newest offerings in Artificial Intelligence Engineering, Music Performance and Music Technology. They may also choose to gain industry exposure through our Professional Experience Year Co-op (PEY Co-op) Program, which this year celebrated its 40th year and its largest-ever cohort of 853 students, one in 10 of whom worked outside of Canada.

Our two campus-linked accelerators, Start@UTIAS and The Entrepreneurship Hatchery, are foundational to U of T's rich entrepreneurial ecosystem. Over the last five years, we have launched more than 80 startups, which have collectively raised approximately $40 million in seed funding. Our Troost Institute for Leadership Education in Engineering (Troost ILead) brings together faculty and instructors with expertise across education, social science, business and engineering to empower and facilitate self-discovery among all our students.

In 2018, we created the Institute for Studies in Transdisciplinary Engineering Education and Practice (ISTEP) to unite faculty, programming and initiatives on a number of curricular themes, including technical communication, leadership, global fluency, business and multidisciplinary design. ISTEP strengthens our position as an innovator and global leader in engineering education.

Undergraduate Engineering Minors and Certificates, Complementary Courses and Inter-Divisional Collaboration

In 2018–2019, we further expanded our suite of minors and certificates that enable students to customize their degrees and specialize in fields from sustainable energy to engineering business. Students in all disciplines can choose from 10 minors and 11 certificates, in which they collaborate with their peers from across the Faculty to strengthen their professional competencies and widen the breadth of their experience.

Students must complete six half-courses to earn a minor, and three half-courses for a certificate. We offer the following minors and certificates:
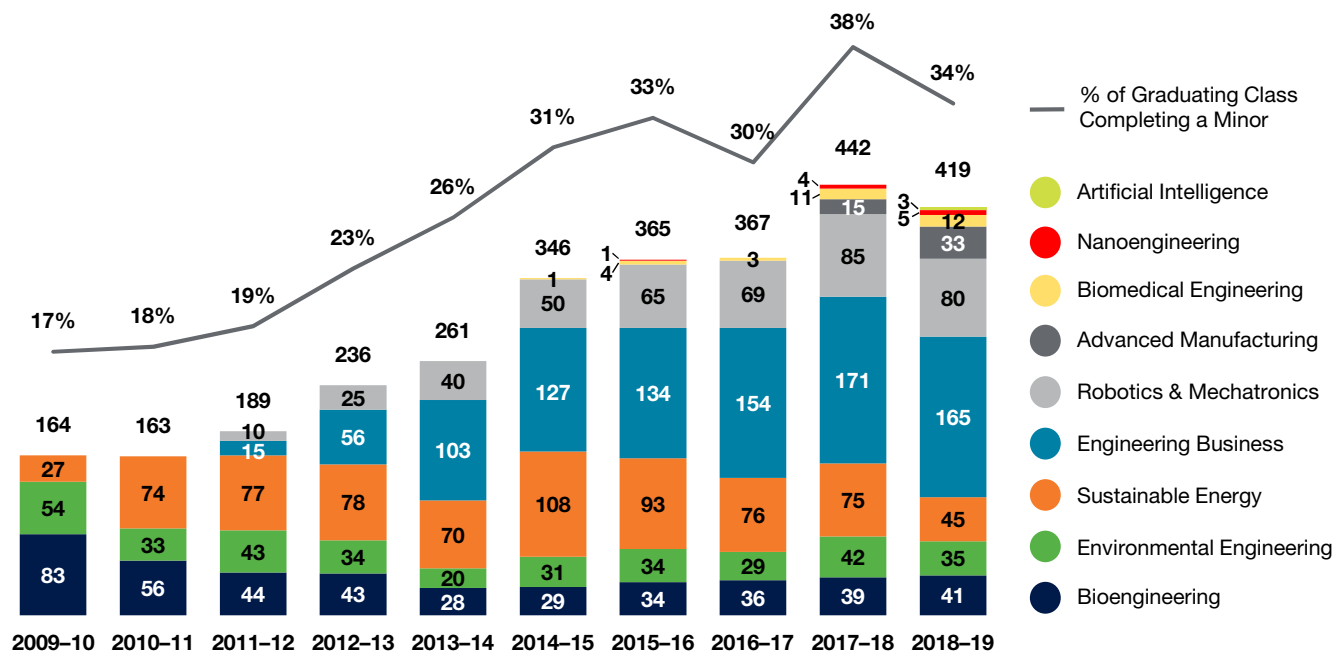
Minors
- Advanced Manufacturing
- Artificial Intelligence Engineering (new in 2019)
- Bioengineering
- Biomedical Engineering
- Engineering Business
- Environmental Engineering
- Music Performance (new in 2018, collaboration with the Faculty of Music)
- Nanoengineering
- Robotics & Mechatronics
- Sustainable Energy

Certificates
- Artificial Intelligence Engineering (new in 2019)
- Communication
- Engineering Business
- Engineering Leadership
- Entrepreneurship
- Forensic Engineering
- Global Engineering
- Mineral Resources
- Music Technology (new in 2018, collaboration with the Faculty of Music)
- Nuclear Engineering
- Renewable Resources

Students may complete more than one minor, and may also complete minors through the Faculty of Arts & Science in areas such as economics, math, sociology, philosophy and history, among others.
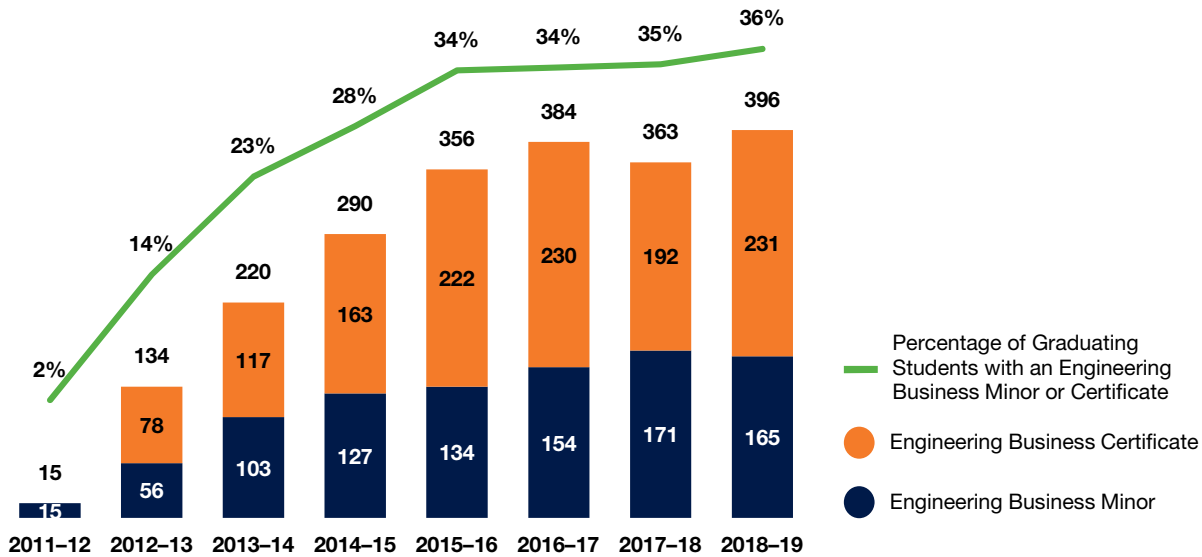
Figure 4.1a **Number of Students and Percentage of Graduating Class Completing an Engineering Minor, 2009–2010 to 2018–2019**

Data and highlights in this chapter are presented for the period from July 2018 to June 2019.
Note 4.1a: A total of 419 minors were completed by 373 students in 2018–2019, with many students completing more than one minor.

Figure 4.1b **Students Graduating with an Engineering Business Minor or Certificate, 2011–2012 to 2018–2019**

Legend:
— Percentage of Graduating Students with an Engineering Business Minor or Certificate
● Engineering Business Certificate
● Engineering Business Minor

Year	Total	Certificate	Minor	Percentage
2011–12	15		15	2%
2012–13	134	78	56	14%
2013–14	220	117	103	23%
2014–15	290	163	127	28%
2015–16	356	222	134	34%
2016–17	384	230	154	34%
2017–18	363	192	171	35%
2018–19	396	231	165	36%

This year, 419 minors were completed by 373 students in the graduating class. More than a third (34%) of this cohort completed at least one minor, and more than half (53%) completed at least one Engineering minor, certificate or Arts & Science minor. Of these, 36% completed either the minor or certificate in Engineering Business, the highest number of graduates for any minor or certificate.

In September 2018, we welcomed the first students into our new cross-disciplinary minor in Music Performance and our certificate in Music Technology. These programs are administered collaboratively by U of T Engineering and the Faculty of Music. The minor includes courses in music theory and a newly created music performance course. Led by Faculty of Music professors and doctoral candidates in performance, the course features weekly individual and group instruction and can be completed either as a soloist or as part of a small ensemble. The certificate focuses on the intersection between the technical and artistic aspects of sound, and prepares graduates to make an impact in areas such as digital music distribution, music production or hardware/software development.

Our newest offerings are the minor and certificate in Artificial Intelligence Engineering, which launched in January 2019. Both of these programs include a new course in AI fundamentals, and additional courses specializing in data mining, neural networks and deep learning.

Undergraduate Design and Research

We incorporate practical engineering design projects into all of our undergraduate programs, across all years of study. By working in multidisciplinary teams to design, build and test prototypes, often in collaboration with external clients, students have the opportunity to develop engineering competencies such as leadership, effective communication, professionalism and entrepreneurship.

First-Year Courses

We offer practical engineering design courses for students in the first year of all our programs. *Engineering Strategies & Practice I and II* courses are for students in TrackOne and Core 8 programs, while *Praxis I and II* are for Engineering Science students.

Praxis students partner with community groups across the Greater Toronto Area to address challenges and enhance daily life. Designs presented at the Praxis showcase in April 2019 included:

- A system to improve safety at the Toronto Tool Library's Makerspace
- New methods to improve locational awareness and navigational abilities of firefighters in active incidents at Toronto Fire Station No. 322
- An improved motorboat transportation system at the Richmond Canoe Club

Upper-Year Courses

Final-year capstone design courses are integrated into every undergraduate program we offer. In addition to their discipline-specific capstone courses, students can also choose to enroll in our *Multidisciplinary Capstone Design Project (MCP)* course through the University of Toronto Institute for Multidisciplinary Design & Innovation (UT-IMDI). In the six years since its creation, more than 550 students from across the Faculty have completed over 120 projects for a wide range of industry clients.

In 2018–2019, 22 student teams comprising 95 students worked with companies and organizations such as the Mill Street Brewery, Defence Research and Development Canada and World Vision Canada. Projects presented at the annual MCP Showcase in April 2019 included:

- Improved earthen flooring design to enhance hygiene in rural Guatemala
- Using machine learning to predict energy consumption in buildings
- Redesigning the lower body of space suits to improve blood flow in microgravity

Undergraduate Research Opportunities

Across all years, our undergraduates engage in research that advances the frontiers of engineering, both within the Faculty and around the world.

The Engineering Science Research Opportunities Program (ESROP) enables Engineering Science students to spend the summer conducting research, both with professors at U of T (ESROP – U of T) and with researchers at partner institutions around the world (ESROP – Global). In the summer of 2019, nearly 50 students, 50% more than in the previous year, went abroad with ESROP – Global to institutions such as Osaka University (Osaka, Japan), Technion (Haifa, Israel), Massachusetts Institute of Technology (Cambridge, U.S.) and the Technical University of Darmstadt (Darmstadt, Germany).

Students in the Core 8 disciplines also have opportunities to conduct research at U of T or abroad through programs administered by the Centre for International Experience. In 2019, a total of 319 students participated in summer research opportunities across all programs. This includes 10 students who were awarded First-Year Summer Research Fellowships, which provide $7,000 in support to students seeking to gain research experience immediately after their first year of study.

Each year, undergraduates across all programs presented their summer research findings at the Undergraduate Engineering Research Day (UnERD). The event features more than 100 posters and podium presentations on topics ranging from advanced materials to sustainable energy.

Figure 4.2a Undergraduate Participation in Summer Research Opportunities, 2010 to 2019
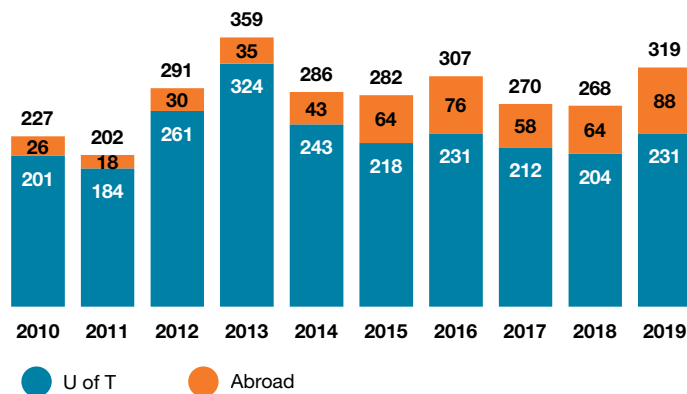
Year	U of T	Abroad	Total
2010	201	26	227
2011	184	18	202
2012	261	30	291
2013	324	35	359
2014	243	43	286
2015	218	64	282
2016	231	76	307
2017	212	58	270
2018	204	64	268
2019	231	88	319

● U of T   ● Abroad

Figure 4.2b Undergraduate Participation in Summer Research Opportunities, by Academic Area, 2019

Research Participation:	U of T	Abroad	Total
ChemE	20	8	28
CivE & MinE	21	2	23
ECE	47	11	58
EngSci	79	51	130
MIE	42	14	56
MSE	20	2	22
TrackOne	2		2
Total	231	88	319

Professional Experience

We offer a wide range of work-integrated learning opportunities that enable students to apply their technical and professional competencies in context, both in Canada and around the world.

The Engineering Career Centre (ECC) provides professional development programming for students through a range of engagement activities designed to facilitate the employment process and a positive transition to the workplace. In 2018–2019 we celebrated the 40th anniversary of ECC's flagship Professional Experience Year Co-op (PEY Co-op) Program. Through PEY Co-op, undergraduates have the opportunity to gain up to 20 months of paid industry experience before graduation. PEY Co-op is the largest program of its kind in Canada. Students have access to more than 360 partner organizations, including large multinationals, startups, government agencies and hospitals.

In February 2019, we launched the inaugural PEY Co-op Awards and Recognition Reception. Awards were presented for Student of the Year, Employer of the Year, Mentors of the Year and Employers of Distinction. In addition, we recognized employers who are going above and beyond in the area of Equity, Diversity and Inclusion. This event acknowledged the strong and longstanding professional relationships between U of T Engineering and industry leaders in sectors from aerospace to software development.

A record 853 engineering students participated in the optional PEY Co-op Program in 2018–2019, representing 71% of eligible students. PEY Co-op students continue to be in extremely high demand: the number of employers hiring U of T Engineering students in 2018–2019 was 368, a 133% increase over the past 10 years. One in 10 PEY Co-op positions was located outside of Canada. The average

annualized salary was $49,308, and the top annualized salary was $105,375.

The ECC is poised to advance its mandate for the 2019-2020 academic year with these initiatives:

- **First-year entry** — ECC now offers students the opportunity to register for PEY Co-op directly during the admissions process.
- **Integration of ECC programs** — Previously, ECC operated the Engineering Student Internship Program (ESIP), which facilitated four-month internships, primarily during the summer term. This program is being combined with PEY Co-op, so that students who sign up in first year now have the option of completing both a four-month internship after their second year, and a PEY Co-op term of up to 16 months after their third year.
- **Professional competencies** — We have appointed a Director, Student Development and Career Programming to advance new programs that enable students to develop competencies in professional communication, teamwork, leadership and the impact of engineering on society. These programs will build on the success of existing initiatives such as the PEY Edge Conference and the Engineering Career Fair.
- **Graduate internship program** —We will expand the benefits of PEY Co-op to our graduate students by launching a professional internship program aimed at MEng candidates. The initial program will partner with companies to create work terms of up to four months.
- **Industry site visits** — We are developing protocols to meet with all PEY Co-op students on site during their work terms to steward industry relationships, assess the quality of the student experience and gather feedback about ways the program could be further improved.

Figure 4.3a Engineering Undergraduate Students Participating in PEY Co-op with Percentage Participation, 2009–2010 to 2018–2019
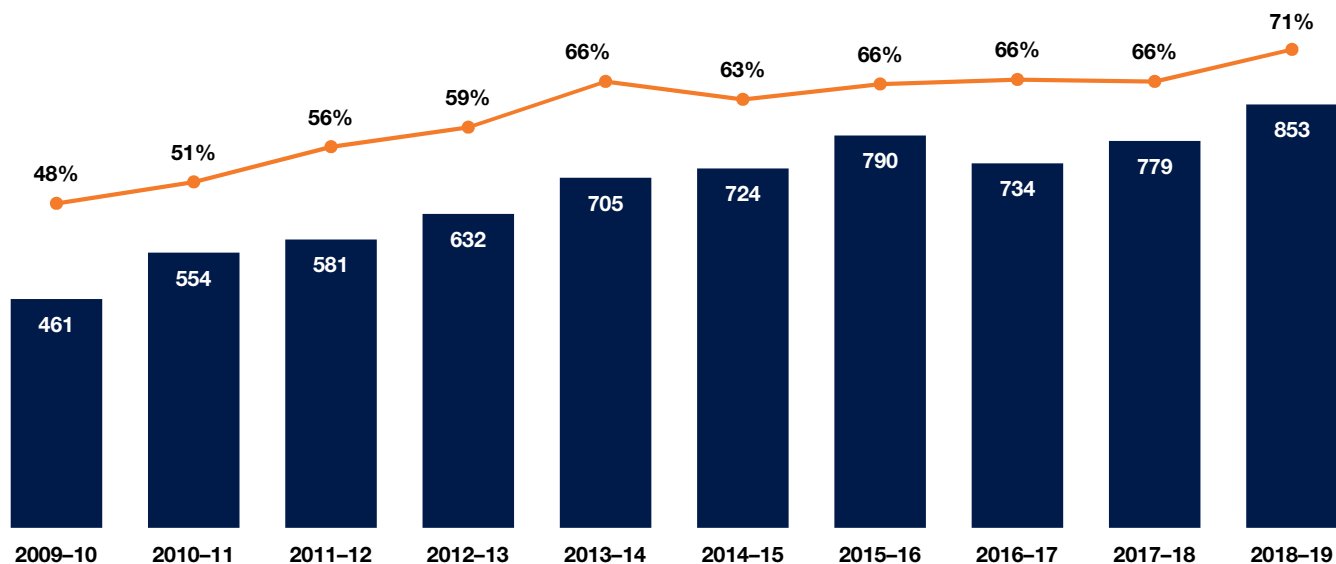

	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19
Students	461	554	581	632	705	724	790	734	779	853
Percentage	48%	51%	56%	59%	66%	63%	66%	66%	66%	71%

Figure 4.3b Canadian and International PEY Co-op Positions, 2009–2010 to 2018–2019

	Canadian Positions	U.S. Positions	Other International Positions	Total Positions
2009–10	426	24	11	461
2010–11	530	11	13	554
2011–12	547	26	8	581
2012–13	592	24	16	632
2013–14	644	36	25	705
2014–15	663	42	19	724
2015–16	711	50	29	790
2016–17	669	49	16	734
2017–18	713	48	18	779
2018–19	768	64	21	853

Figure 4.3c PEY Co-op Employers, 2009–2010 to 2018–2019

	PEY Co-op Employers who Hired Engineering Students
2009–10	158
2010–11	185
2011–12	221
2012–13	241
2013–14	304
2014–15	317
2015–16	310
2016–17	337
2017–18	318
2018–19	368

Note 4.3a: Percentage participation is calculated by dividing the number of completed PEY Co-op positions by the number of eligible students (i.e. the third-year cohort from the previous year).

Student Entrepreneurship

Through both curricular and co-curricular programs, we offer strong support for undergraduate and graduate students who are interested in entrepreneurship. We provide access to mentorship, fabrication facilities, seed funding and office space to enable our community members to translate their innovations from concepts into viable, market-ready products. We integrate our efforts with other programs available across U of T to form a rich ecosystem of entrepreneurship support.

Curricular Programs

Students in our Core 8 streams can complement their technical studies with an Engineering Business minor or certificate, or a certificate in Entrepreneurship, Innovation & Small Business. For Masters of Engineering students, the Entrepreneurship, Leadership, Innovation & Technology in Engineering (ELITE) emphasis prepares them to lead in business and entrepreneurial enterprises.

The Entrepreneurship Hatchery

Established in 2012, The Entrepreneurship Hatchery provides a comprehensive suite of programs and services to nurture a culture of entrepreneurship across the Faculty. Over the last five years, the Hatchery has launched more than 80 startups, including many based on U of T Engineering research. To date, these companies have collectively raised more than $40 million in seed funding.

Events such as the weekly Idea Markets, Hatchery Speaker Series, Co-Founders Day and Accelerator Weekend enable students with a drive to create their own companies to meet and interact with each other, and with experienced mentors from a variety of fields. These experiences spark collaborations and help form teams that enter Hatchery programs.

Hatchery NEST

This rigorous summer program guides student teams as they turn their business ideas into companies, including designing and creating prototypes or minimum viable products. Over four months, students receive mentorship and advice from seasoned professionals in intellectual property, marketing, finance and other areas of business development. They also have access to fellowships, work space and prototyping facilities featuring 3D printers, laser cutters, tools and materials.

In 2018, Hatchery NEST received 118 applications and accepted 38 teams, 13 of which competed at the annual Hatchery Demo Day in September 2018, where they pitched their startups to investors and the U of T community. The winners included:

- **Grid** — Grid uses wide-angle cameras programmed with image recognition technology to detect available parking spaces and broadcast their location in real time, so drivers can navigate to the available spot or reserve a parking space before setting out. The system also provides parking lots with real-time analytics, allowing them to introduce dynamic pricing models.
- **Voco** — Voco is a platform that allows audio content creators and advertisers to easily upload their content to all smart speakers. Just as Spotify works for music, Voco would enable users to search for audio news, commentary, comedy or drama, all via voice command.
- **Knowtworthy** — Knowtworthy's software provides real-time automated transcription of meeting minutes, instant action items that can be linked to team members' calendars, and provides personalized reports to each member on how to improve their communication skills by providing metrics on a team member's engagement or openness to ideas.
- **Zeroth Responders** — Using the Zeroth app, volunteers trained in CPR or first aid would be alerted if someone nearby is in distress. The goal is to reduce response times for medical emergencies and keep patients stable until paramedics arrive.

Hatchery LaunchLab

Established in fall 2016, the Hatchery LaunchLab provides support for research-driven startup companies led by graduate students and faculty. Teams benefit from enriched support including legal counsel, accounting and marketing services, an advisory board composed of experts in technical and business development, mentors with experience in the industries in which the startups hope to compete and funding for an extended incubation period of one to two years. LaunchLab equips teams to sustain themselves while they complete the development necessary to deliver proof-of-concept for their technology and attract investment from venture capitalists.

Teams currently part of Hatchery LaunchLab include:

- **Pliant Power Devices** — Pliant creates electrically conductive plastics for next-generation batteries.
- **Phycus Biotechnologies** — Phycus produces bio-based ingredients for personal care products.
- **Amber Molecular** — Amber develops organic light-emitting diodes for electronic displays and interior lighting.
- **Iconthin Biotech Corp.** — Iconthin leverages microfluidics to grow microalgae that produce nutritional supplements, such as astaxanthin.

Institute for Studies in Transdisciplinary Engineering Education and Practice (ISTEP)

Created in 2018, the Institute for Studies in Transdisciplinary Engineering Education and Practice (ISTEP) is reshaping the way our Faculty educates engineers, preparing the next generation to contribute to society, build a prosperous economy, and enjoy lifelong career growth in an increasingly complex and global environment.

Under the direction of Professor Greg Evans (ChemE), ISTEP consolidates and expands our graduate and undergraduate programming in communication, leadership, business, entrepreneurship and engineering education. It also brings together faculty members engaged in the scholarship of teaching and learning to improve pedagogy, enhance learning and growth, and foster the transdisciplinary competencies necessary for future success.

ISTEP comprises the following six areas:

- The Engineering Communication Program, which for more than 20 years has been a leader in teaching and research in professional communication;
- The Troost Institute for Leadership Education in Engineering, which conducts research and builds programming to help students discover and enhance their leadership potential;
- The Centre for Global Engineering, a cross-disciplinary hub for research projects that address some of the world's most pressing challenges;
- The undergraduate-level Engineering Business minor, the most in-demand of the Faculty's 10 multidisciplinary engineering minors;
- The undergraduate certificate in Entrepreneurship Innovation and Small Business; and
- The graduate-level Collaborative Specialization in Engineering Education (EngEd)

ISTEP now has 11 faculty and more than 30 adjunct and sessional instructors.

The major contributions of ISTEP to teaching and learning in 2018–2019 include:

- **Specialized courses** — ISTEP led the delivery of more than 30 courses that focus on engineering competencies such as communication (10 courses), leadership (14 courses), business & entrepreneurship (five courses) and engineering education (three courses).
- **Embedded learning** — ISTEP faculty collaborated with professors across U of T Engineering to integrate the instruction of transdisciplinary competencies into 20 design and other technical courses. This instruction of communication and team skills enhanced the learning experience for students across each of the Faculty's undergraduate programs.
- **Ethics and equity** — Workshops on ethics and equity were developed from 15 case studies based on interviews with engineers across diverse career trajectories and piloted in eight engineering courses.
- **EngEd** — Two MASc students graduated last year from the Collaborative Specialization in Engineering Education (EngEd) program. Currently, 13 PhD students are enrolled in the program, including seven from Engineering and six from the Ontario Institute of Studies in Education (OISE). The Graduate Program in Higher Education at OISE joined the specialization last year.
- **OPTIONS** — The Opportunities for PhDs: Transitions, Industry Options, Networking and Skills (OPTIONS), an initiative led jointly by the Vice-Dean, Graduate Studies and Troost ILead, prepares PhD students and postdoctoral fellows for careers outside academia. More than 30 students completed all requirements of the OPTIONS program in the fall of 2018, with a total of 229 participating in complementary events associated with the program. *(For more information on OPTIONS, see Chapter 2: Enriching the Graduate Student Experience)*

ISTEP increased its research and scholarship on engineering education and the development of professional skills and competencies, such as:

- **Engineering education and professional development** — ISTEP faculty are active in the leadership of a number of professional associations, including the Canadian Engineering Education Association (CEEA) and the American Society for Engineering Education (ASEE). The Faculty hosted the IEEE Professional Communication Conference in July 2018, which drew participants from all over North America and Europe.
- **Skills development and assessment** — ISTEP helped to develop major research proposals on skills development and assessment to the federal Future Skills Centre initiative and provincial Higher Education Quality Council of Ontario.
- **Work-integrated learning and leadership** — In collaboration with the Engineering Career Centre, the PEY Co-op Project began exploring ways to enhance work-integrated learning. The Engineering Leadership Project examined how engineers learn to lead at all stages of their careers.
- **Data analysis** — At the national level, Statistics Canada data were analyzed to explore the transition from university to the workforce and new questions were added to Engineers Canada's Final Year Student Exit Survey to provide a national snapshot of the leadership competencies of engineering graduates.

Engineering Communication Program (ECP)

The Engineering Communication Program provides support to all students and is a leading centre for teaching, research and professional communication in engineering. Its programming is integrated into courses across the curriculum from first to fourth year. Writing and communication workshops and one-to-one tutoring are also available to students through ECP.

In 2018–2019, more than 1,000 students received communication support through ECP's tutoring service and demand for this support continues to increase. ECP also coordinates the undergraduate certificate in Communication, launched in 2015–2016, which leverages eight humanities and social sciences electives offered by ECP faculty since 2008, with a ninth set to be launched in 2019–2020.

Our Faculty has been very successful in attracting increased numbers of international students. ECP has supported this transition by growing the support it provides, including professional language support for multilingual students. In 2015–2016, ECP piloted the Diagnostic English Language Needs Assessment (DELNA) for all incoming first-year students, enabling identification of those who may experience challenges participating in their lectures, tutorials or team projects. Partnering with Queen's University, faculty developed a suite of assignment-specific workshops, increased the capacity of the Tutoring Centre to work with multilingual students, tracked student progress in second and third year, and produced an 8-module *Interventions for Engineering Communication Development* resource to be published online under a Creative Commons license.

Troost Institute for Leadership Education in Engineering (Troost ILead)

The Troost Institute for Leadership Education in Engineering prepares students to maximize their impact as engineers, innovators and leaders by providing transformative curricular and co-curricular learning opportunities. Troost ILead also conducts academic and industry-focused research and outreach to engineering leadership educators and engineering-intensive enterprises.

Troost ILead offered six undergraduate and eight graduate courses in 2018–2019. MEng students can count these courses toward the Entrepreneurship, Leadership, Innovation & Technology in Engineering (ELITE) certificate, while undergraduate students can earn credits toward the minor in Engineering Business or the certificate in Engineering Leadership. Demand for these courses was strong, with overall enrolment reaching 672, a 14% increase from the previous year.

Engineering students also gained opportunities to hone their leadership competencies and self-development through Troost ILead's innovative co-curricular programs. In 2018–2019, Troost ILead offered 24 co-curricular Leadership Labs that reached more than 1,000 students. Moreover, these labs provided work experience for four students who were trained as co-facilitators. A further nine students participated in the 16-week Troost ILead Summer Fellowship. Students developed strategies for organizational development, peer learning and individual coaching, to help them increase the impact of their student organizations. Thirty students participated in the Faculty-wide Summer Leadership Program. This eight-week series of workshops provides students with opportunities to better understand their strengths and values, and gain new perspectives on engineering and its impact on society.

Troost ILead's research efforts in 2018–2019 involved three different project types: insight research, pedagogical and programmatic innovation research, and secondary analyses of large-scale data sets with associated knowledge mobilization. Updates from the Engineering Leadership Project and the PEY Co-Op Project were presented as part of two Community of Practice Workshops that brought together industry partners, faculty and students to further explore the findings. Troost ILead also hosted four well-attended seminars with speakers from Pennsylvania State University, Purdue University, Western University and Colorado School of Mines.

Student Clubs and Teams

U of T Engineering is home to more than 100 student clubs and teams. Some of these groups, such as the University of Toronto Aerospace Team, the aUToronto team, and the Blue Sky Solar Racing team, compete in and win intercollegiate contests across North America and around the world. Others, such as Skule™ Nite, the Spark Design Team and the Skule™ Orchestra, emphasize cultural or artistic pursuits, further enriching the student experience.

All undergraduates can document their co-curricular activities in the U of T Co-curricular Record, an official report that offers recognition for competencies gained through athletic teams, student government, cultural clubs, design teams and other campus organizations.

The Centralized Process for Student Initiative Funding (CPSIF) allows student groups to apply to various funding sources within the Faculty via a single application. In 2018–2019, 92 undergraduate and graduate engineering student groups and initiatives shared a total of $368,669.36 through CPSIF.

A complete list of student clubs and teams is available in Appendix D.