A Leadership-Development Ecosystem for Engineering Graduate Students

Teresa J. Didiano, University of Toronto

Teresa Didiano is the Graduate Professional Development Coordinator at the Troost Institute for Leadership Education in Engineering at the University of Toronto. She designs and coordinates leadership and professional development programs for graduate students and postdoctoral fellows to explore diverse career pathways. Teresa has an HBSc and MSc from the University of Toronto, and Life Skills Coaching Certification from George Brown College. She also is a certified MBTI Practitioner and recently completed Stanford University's Life Design Training.

Ms. Annie Elisabeth Simpson, Troost Institute for Leadership Education in Engineering, University of Toronto

Annie Simpson M Ed is the Associate Director or Troost ILead. She oversees ILead's co-curricular programs and manages the programming team. As a long standing member of the team, Annie has been engaged in the development of many programs and in the establishment of ILead culture. Annie developed 'The Power of Story: Discovering Your Leadership Narrative," and taught the course for its first four years. She also supports ILead's growing community of Instructors. Before coming to U of T Annie taught in the community college system and also worked as a counselor, conflict mediator and restorative justice facilitator and trainer. Annie is committed to transformative education that engages the whole person. She is inspired to cultivate the emotional intelligence and leadership effectiveness of students, staff and professionals. She is a certified Search Inside Yourself teacher; a mindfulness-based emotional intelligence program for leaders.

Dr. Doug Reeve P.Eng., University of Toronto

Dr. Reeve was the founding Director (Emeritus) of the Troost Institute for Leadership Education in Engineering (ILead) (2010-2018) at the University of Toronto. After a lengthy career as a consulting engineer he made development of personal capability central to his work with engineering students, undergraduate and graduate. In 2002 he established Leaders of Tomorrow, a student leadership development program that led to the establishment of ILead in 2010. He is a Professor in the Department of Chemical Engineering and Applied Chemistry and ILead.

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Abstract

There is a rapidly growing body of literature on engineering leadership education for undergraduate students [1, 2, 3]. However, there is little published about leadership development for graduate students. There have been calls from national bodies to create and expand professional development opportunities for graduate students [4-6], and leadership education is ripe to complement highly technical disciplines. Leadership education cultivates self-awareness, clarifies personal vision, and hones interpersonal and teamwork competencies. These critical skills enhance the experience of students in their studies and prepare students to succeed in their future careers.

In this paper we discuss how the Troost Institute for Leadership Education in Engineering at the University of Toronto supports the leadership development of graduate students, including PhD students and research- and professional-based Masters students. We approach leadership education for graduate students by fostering a vibrant learning ecosystem including three learning environments: for-credit courses, co-curricular programming, and practical leadership experiences. We aim to: 1) cultivate graduate student self-leadership, 2) support the emergence of personal vision, and 3) create opportunities for community building and connection.

We offer seven, graduate-level courses but highlight four here – one on emotional intelligence, one on personal values, one on presentations, and one on positive psychology. Each of these courses aims to foster greater self-awareness, confidence, and personal vision. The second learning environment is The OPTIONS Program, a professional-preparation, cohort-based program that supports graduate students and postdoctoral fellows in exploring diverse career pathways. Through this program participants envision and move towards their desired future. The third learning environment is ILead:Grad, a student-led group that coordinates workshops and events to foster a culture of leadership development. By working in a team and building a shared vision, students get the experience of collaborating with others to design initiatives, making decisions as a group, and leading in their community.

We conclude the paper with a list of recommendations to support educators to create opportunities for graduate students to engage with leadership development.

Introduction

Engineering graduate studies immerse students in a robust technical training that equips them to solve complex problems and generate innovative solutions to scientific and societal challenges. In recent times, national organizations have called for broadening of graduate education beyond the technical to include career development and professional skills training [4-6]. The impetus is that traditional graduate degrees prepare students to become professors and researchers at educational institutions while career outcome studies show that those with engineering graduate degrees find employment in a wide range of industries such as healthcare, banking, aerospace, consulting and manufacturing [5, 7, 8]. In Canada only 14% of engineers with PhDs (including architecture and related technologies) are employed as professors [4].

There is a need to provide leadership-learning opportunities to engineering students as leadership competencies can boost their success in school and in the workforce [9, 10]. Leadership education inspires students to move beyond the technical to become sociotechnical leaders who can leverage their strengths, guide with a personal vision, communicate their value, navigate interpersonal dynamics, and collaborate in multi-disciplinary teams. Many institutions are infusing leadership learning into the engineering undergraduate experience [1-3].

There are fewer institutions that have created leadership development initiatives for graduate students. For example, the University of British Columbia has a Masters in Engineering Leadership that provides leadership and industry-specific technical training to professional engineers [2]. Similarly, Tufts University has a Master of Science in Engineering Management targeted at working professionals who wish to develop their business, strategic thinking, and leadership skills [11]. At Northeastern University professional engineers or interns completing a master's degree can simultaneously earn a Graduate Certificate in Engineering Leadership through courses and workshops [12].

The goal of this paper is to share how the Troost Institute for Leadership Education in Engineering (Troost ILead) at the University of Toronto (U of T) develops graduate students' leadership potential. We discuss our approach to leadership and how it applies to graduate students. We then provide an overview of our leadership learning ecosystem and its three learning environments: for-credit courses, co-curricular programming, and a practical leadership experience. We discuss the pedagogical approaches that: 1) foster reflective self-leadership; 2) support the emergence of personal vision; and 3) create learning communities. We conclude by sharing recommendations for engineering educators to implement engineering-graduate-student-specific, leadership development initiatives at their institutions.

Context
The Faculty of Applied Science and Engineering at U of T is home to approximately 3000 graduate students and postdoctoral fellows and 5000 undergraduate students. The graduate student population is divided equally into three degree-programs, PhD, research-based Masters, and course-based, professional Masters. Of all graduate students, 29% identify as women and 42% are registered as international students. U of T graduate students and postdoctoral fellows find employment in many sectors. Among PhD graduates, 26% are employed in tenure stream positions, 18% in other post-secondary education roles (e.g., research associate, adjunct professor), and 55% in the private and public sector [7]. For postdoctoral fellows, 31% go on to be employed in tenure stream positions, 24% in other post-secondary education roles, and 31% in the private or public sector [13].

Our Approach to Leadership
For over a decade, Troost ILead has engaged engineering students in leadership development through curricular and co-curricular offerings. Our vision is 'engineers leading change to build a better world'. We believe leadership is a process that begins with the self, and is guided by values, vision, and vitality, to inspire and empower teams and organizations to make positive change [14]. Although our work began with, and has been predominantly focussed on, undergraduates, we approach graduate student leadership education differently.

Institutional factors have led to significant growth of programming in the graduate sphere. The nature of a research-based graduate degree (i.e., less course work, more independent research) affords students greater time and flexibility to engage in leadership programming. Graduate students also have more autonomy in course selection whereas undergraduate degree requirements are more rigid. The Vice Dean, Graduate Studies, both current and former, have prioritized professional development training and fostered greater community engagement which has generated funds for enrichment opportunities and a new full-time position for a student affairs professional dedicated to graduate programming. Presently, we offer more graduate than undergraduate courses.

Many graduate students are motivated to engage in leadership learning because they have some professional work experience and recognize the value of leadership skills in the workplace. The largest group of participants that attend our programming are students in the course-based, professional Masters. This group typically has some work experience or are international students that are keen to learn about workplace culture in Canada. In comparison, our undergraduate students are more likely to seek opportunities that directly support them in boosting their success on teams, supporting their leadership of student groups, or finding and preparing for a job.

As to content, we place a significant emphasis on self-exploration in both the undergraduate and graduate space. However, graduate students are positioned to dive more deeply into personal reflection due to their maturity, and work and life experiences. This allows us to offer more one-on-one engagement. We target graduate students near the end of their degree so our co-curricular programs for graduate students focus on the connection between self-exploration and career planning. In contrast, our undergraduate programming places a greater emphasis on self-awareness, interpersonal relationships, and leading in teams. These are leadership skills that students can apply immediately to academic courses and student groups.

Our Graduate Ecosystem's Three Learning Environments
We offer three types of graduate programming: 1) for-credit courses; 2) a career exploration and professional development, co-curricular program; and 3) a practical leadership experience. Below we describe these learning environments and detail some of our pedagogical approaches. Data presented in this paper was collected with approval from our ethics review board for course and program quality and improvement, not for research.

For-credit Courses
After successfully launching our first undergraduate-graduate course in 2007, we offered our first graduate-only course in 2010. Within a few years we built a suite of eight graduate courses taught by instructors and practitioners, engineers and non-engineers with experience in a range of subjects: engineering, leadership, education, psychology, business, and executive coaching [15, 16]. In the 2019-2020 school year, 226 graduate students completed a Troost ILead course with 175 of those students being enrolled in course-based, professional Masters degrees. Each course has thirty-nine hours of instruction over thirteen weeks and typically has twenty to fifty students. Smaller class sizes are preferred to enable in-depth discussion and individual attention. Each course offers a deep dive into a range of leadership topics such as emotional intelligence, personal values and vision, positive psychology, career management [17], engineering

presentations, and leading in design projects, teams, and organizations. Our leadership courses are consistently ranked higher than the average course rating in the Faculty for quality learning experience. Below we describe four of the courses we offer.

'The Science of Emotional Intelligence and its Application to Leadership' is grounded in self-leadership and personal discovery. It is taught by a consultant/executive trainer. The course teaches students the competencies of emotional intelligence, and their relationship to leadership effectiveness and resilience. Students learn about the neuroscience of mindfulness and experiment with their own mindfulness practice, both to improve focus and attention but also to gain greater self-awareness. Each student completes an EQI 2.0 Assessment by the Multi-Health Systems Inc. [18], and a one-on-one, forty-five-minute debrief with the instructor. The EQI 2.0 Assessment measures EQ competencies related to self-expression, self-perception, stress-management, decision-making, and interpersonal relating. Students experience increased clarity with respect to their strengths and areas for growth. They then create a personal development plan which they work on throughout the rest of the course.

'Authentic Leadership: Engineering our Vibrant Future' is taught by two executive coaches. The course challenges the notion that leadership is a prescribed set of behaviors and encourages students to explore their own authentic leadership rooted in their personal values. A central pedagogical tool used in this course is the Values Operating System developed by Pursuit Development Labs Inc. [19]. As a first step, students identify, rank and select their top ten values from a comprehensive list. This is followed by an in-person session where students distinguish where each value lives on their personal values map. The value groupings on the map distinguish: 1) the values we draw on when collaborating with others; 2) the values we need to feel a sense of connection and creativity; and 3) the values we draw on when tired and in need of spiritual renewal. This process is highly personalized; everyone's value system is unique. As students come to understand and align with their own values system, they gain a greater appreciation for the values systems of others. Each student then crafts a purpose statement that reflects their own values and articulates where they find meaning. As in the emotional intelligence course, this course involves coaching, both in peer groups and, informally, with course instructors. The second half of the course is geared towards supporting students to apply their newly articulated authentic leadership to a change project. Class discussions reinforce the ideas that leadership can be expressed in a variety of ways and that alignment with our values fuels our personal power and confidence as leaders.

'Engineering Presentations' is a course that recognizes communication as a critical success factor in engineering. It is taught by an engineering professor. Engineering and scientific know-how are given added power when communicated with clarity and simplicity in presentations that are thoughtfully planned and effectively executed. Each student makes a large number of short presentations to sharpen their skills and increase their confidence. Students grapple with capturing the essence of complex technical subjects and expressing it through key words, data and images. Students develop a wide range of skills: visual representation of data, systems and mechanisms; structuring and sequencing a talk; delivering speeches with vivid voice and body language; and finally, skills in connecting with an audience and achieving the desired impact. Each time a student presents they are asked to reflect: "What did you observe about yourself in this exercise?" exploring their own emotional and physical responses to the pressure of

presenting to an audience. This work requires a community of learners who serve as a thoughtful, empathetic, and yet still critical, audience who provide peer feedback.

The fourth course, 'Positive Psychology for Engineers', is better known as 'The Happy Engineer'. Students embark on a journey of self-discovery and community building. The course is "adventure-based" and uses local art galleries, toy stores, and even cemeteries as a backdrop for self-exploration and meaningful conversations. Students practice self-awareness, self-evaluation, self-exploration mind-mapping, and reflective writing to deepen their personal learning. For example, on a trip to a toy store, students are encouraged to reflect on their inner child and reconnect with the spirit of play. Similarly, on a trip to a cemetery, students engage in guided reflection on life's fleeting nature and how they want to spend their time. Weekly, team-based activities and conversations help students connect with each other and build a sense of collective growth and community. Engineering concepts like balance, flow, feedback, amplitude, dynamic equilibrium and others are used to explore the ways a student's technical knowledge contributes to deep understanding of happiness. This challenges students to explore happiness as it relates to their own personal development - in service of their becoming better engineers. This course encourages students to trust themselves and follow their own internal compass as they carve out a personal and professional path. It prioritizes student mental and emotional health.

In addition to standardized Faculty course evaluations, we have collected supplementary feedback to evaluate the impact on students' leadership learning and identity (Table 1). The table shows that students who take these leadership courses make progress on their understanding and identification with leadership and in their ability to contribute as an engineer.

Table 1. Student Feedback on Courses

At the conclusion of each course, students complete a supplementary feedback form to evaluate their leadership learning and identity development using a Likert scale of one for Strongly Disagree to seven for Strongly Agree. For Course 1 we have data from two sections in 2015 and 2016, and one section in 2017, 2019, and 2020. For Course 2 we have data from two sections in 2017 and one section in 2015, 2016, and 2020. For Course 3 we have data from 2014, 2016, 2017, and 2018. For Course 4 we have data from two sections in 2015, and one section in 2014, 2016, and 2020. Data presented was collected with approval from our ethics review board for course quality and improvement, not for research.

	Course 1	Course 2	Course 3	Course 4
	The Science of Emotional Intelligence and its Application to Leadership	Authentic Leadership: Engineering our Vibrant Future	Engineering Presentations	Positive Psychology for Engineers
	Average Response			
I will be a better leader for having taken this course.	6.2	6.5	5.8	6.0
This course has increased my motivation to continue to learn to be a better leader.	6.3	6.6	6.0	6.2
This course has provided me with knowledge that will help me learn to be a better leader.	6.3	6.6	6.1	5.9
This course has increased my understanding of the nature of leadership.	6.1	6.5	5.4	5.8
This course has increased my understanding of myself as a leader.	6.3	6.6	5.6	6.1
This course has enhanced my ability to contribute as an engineer.	5.7	6.1	6.1	5.9
Number of Respondents	150	105	71	167
Number of Course Sections	7	5	4	5

Career Exploration and Professional Development Co-curricular Program

In 2017 a working group consisting of engineering professors, a leadership educator, a communication instructor, and career educators set out to create The OPTIONS Program (Opportunities for Professional Careers: Transitions, Industry Options, Networking and Skills). The program's aim is to support graduate students and postdoctoral fellows to develop their leadership and professional skills, and explore diverse career pathways, especially careers outside the academy [20]. In OPTIONS participants learn to: 1) formulate a career exploration plan through personal reflection and self-awareness; 2) articulate their skills and experiences in job application materials; and 3) use networking tools and labour market resources to explore career options. We emphasize personal reflection and community building.

OPTIONS is a non-credit, cohort-based program with two-hour sessions offered weekly for nine weeks. In addition to receiving and discussing content, participants develop a career exploration plan and are placed in a peer success team. Participants also engage in: an informational interview; a mock interview; a twenty-minute, one-on-one resume and cover letter review with

an instructor; and two, thirty-minute, one-on-one conversations, one with a professor and one with a career coach. Each year, we host one cohort for course-based Masters students and one cohort for PhD students and postdoctoral fellows. To date, we have had over 200 participants in eight cohorts, six in-person and two online. Participants apply to be part of the program, and we select participants that are near the end of their degree and that have a strong interest in career exploration.

To cultivate participants' self-leadership we use the Bolton and Bolton Work Styles Inventory. This an eighteen-question inventory that places participants in one of four styles: driver, analytical, amiable, and expressive [21]. After completing the inventory, participants discuss how to optimize their performance in teams given their style and their awareness of the styles of others. They consider how to integrate their leadership style when showcasing their uniqueness in preparing job applications materials and interview responses. After participants completed the inventory and debrief, we found significant increases in their confidence to: explain my own leadership style; and leverage my leadership style to work in teams (Table 2).

Participants create a career exploration plan rooted in self-reflection and action-planning using two, gamified, narrative assessment tools developed by OneLifeTools. The first tool, *Who You Are Matters! A Career and Life Clarification Game*, is a conversational group experience where participants reflect on their strengths, personal qualities and desires. The second tool is the *Online Storyteller*, a self-directed experience in which participants individually reflect on their past experiences to identify their skills and strengths. Through these tools, participants generate three career possibilities and a plan to explore them [22]. They debrief their findings in a thirty-minute, one-on-one session with a career coach. As a result of using these tools, we found participants' confidence increased substantially with respect to: creating an actionable, career exploration plan; verbalizing goals and aspirations; and explaining strengths, interests, personal qualities, and assets (Table 2).

To support participants to develop deeper connections with their peers and to be exposed to a range of career possibilities, we use peer success teams. These teams consist of four or five participants and are diverse by participant degree, discipline, gender, and Bolton and Bolton Work Style. Participants provide feedback on their peers' resumes and cover letters, and participate in a group informational interview and job interview. With these teams, our aim is to create personal and career support networks. The post-evaluations showed that participants left the program with increased confidence in building working relationships with others (Table 2).

Table 2. Student Development during the OPTIONS Program
Participants complete a pre- and post-evaluation where they assess the change in confidence in their skills for twenty-one indicators that align with the program's learning outcomes. Responses are measured on a five-point Likert Scale: 1 for Strongly Disagree; 2 for Disagree; 3 for Neither Agree nor Disagree; 4 for Agree; and 5 for Strongly Agree. The table provides data for six cohorts. For the pre-evaluation N = 155 except for * where N = 130 as data was not collected for one cohort. For the post-evaluation N = 140, except for * where N = 113 as data was not collected for one cohort. Percent change is calculated as the average response post-evaluation subtract the average response pre-evaluation, divided by the average response pre-evaluation. Data presented was collected with approval from our ethics review board for program quality and improvement, not for research.

Pedagogical Approach	I am confident as of now...	Percent Change (%)
Bolton and Bolton Work Styles Inventory	I can explain my own leadership style.	34
	I can leverage my leadership style to work in teams*	18
Narrative Assessment	I can create an actionable, career exploration plan to investigate three possible career options.	52
	I can verbalize my goals and aspirations in a career statement.	35
	I can clearly explain my strengths, interests, personal qualities, and assets.	22
Peer Success Teams	I can effectively building working relationships with others.	8

In an open-ended portion of the post-evaluation we asked: "What do you like about the program?" The responses, in order of frequency, were: 1) learning practical skills for the job search such as resume and cover letter writing, informational interviews, and job interviews; 2) the collective community experience through which participants built relationships, completed team activities, and had group discussions; and 3) time for personal reflection and self-awareness development to clarify personal vision and next career steps.

The OPTIONS Program also offers complementary events throughout the year open to all graduate students and postdoctoral fellows. These events range from short, skill-building workshops (e.g., networking, personal branding, and resumes), to panels on career exploration, alumni networking events, and full-day workshops on Stanford University's Design Your Life [23] and the Search Inside Yourself Leadership Institute program [24].

A Practical Leadership Experience
Established in 2006, ILead:Grad is a faculty-wide, student-run group whose objective is to inspire graduate students to develop their leadership skills as they contribute to the school community and beyond. They realize their objective by empowering individuals, cultivating a positive environment, and making an impact. The group is led by an executive team of students who are passionate about personal growth and leadership. The team consists of two co-chairs, administrative directors, event coordinators, communication directors, treasurer, and webmaster. Each year, they host eight to ten events open to all graduate students and postdoctoral fellows, and typically reach between 250 to 500 participants. Some examples of events include panels on leading your career exploration, entrepreneurship, and law, skill-building workshops on public speaking, conflict management, self-care, and leadership styles, and community building events such as mock networking and the joy of reading. The group operates independently under the umbrella of Troost ILead with some staff oversight.

This student group is a pedagogical vehicle where students can apply and experiment with leadership in a practical team experience. The group is responsible for developing a shared vision, understanding the needs of the students they serve, and collaborating to brainstorm, coordinate, and implement initiatives. Students develop skills in organizing events, communicating the value of leadership development, financial management, decision-making, and organizational operations. In addition, the co-chairs (i.e., leaders of the group) gain experience in leading a team, and creating a positive, trusting group experience where their peers can realize their full leadership potential.

Using student groups as a means to teach leadership has benefits for student leaders, Troost ILead, and the graduate community. First, student leaders actively practice interpersonal and organizational leadership in ways that they cannot in a course or co-curricular program. Their engagement also brings rewards beyond their growth as leaders as they expand their network of peers, alumni, student affairs professionals, and faculty. Second, the group supports Troost ILead in spreading our mission and achieving our objectives. And third, they cultivate a culture of leadership development in the graduate community which motivates leadership learning.

Recommendations
We have three recommendations for engineering educators interested in implementing graduate-student-specific leadership development initiatives. First, community is a critical component of a positive graduate experience. At U of T, our research-based students spend time conducting research in isolation and course-based, professional Masters students lack a cohort due to great flexibility in their course selection. We recommend designing interactive, active learning, cohort or team-based initiatives to create a space where students can meet their peers and grow their networks. Leadership instruction is, in part, about social development and we lead in the context of relationships.

Our second recommendation relates to hiring of instructors. We know that a small fraction of graduate students will remain in academia and become professors, while the majority will find professional roles elsewhere. For this reason, our course instructors and guest facilitators have industry experience or professional roles beyond the university. For example, we hire management consultants, psychologists, executive coaches, and entrepreneurs. These credible practitioners bring a wealth of expertise and expose students to rich perspectives and workplace experience.

Our final recommendation is to design leadership programming in collaboration with key partners to create a scaffolded learning experience, expand your student audience, and access funding. We have formed a fruitful partnership with the Vice Dean, Graduate Studies who has supported the development, promotion, and delivery of The OPTIONS Program. In addition, we also offer our leadership courses as part of the Vice Dean, Graduate Studies' Entrepreneurship, Leadership, Innovation and Technology in Engineering Certificate. We also partner with the Faculty's Career Centre that offers graduate professional internships where a recommended requirement is that students complete one of our leadership courses. Partnerships increase our reach and impact, and help us remain alert to institutional opportunities, students' changing needs, and larger organizational and global trends.

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