UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Dean's Task Force on Engineering Leadership Education

Final Report

May 5, 2010

Doug Reeve (Chair)
Shahed Al-Haque
Phil Byer
Dave Colcleugh
Bryan Karney
Chris Langan
Maygan McGuire
Lisa Romkey
George Roter
Ian Simmie
Annie Simpson
Angela Tran

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Summary and Recommendation of the Task Force on Engineering Leadership Education

Dean Cristina Amon established the Task Force on Engineering Leadership Education in the Faculty of Applied Science and Engineering in October 2009. The Task Force was to review the advances made by the Engineering Leaders of Tomorrow (LOT) program and develop strategic options for the future.

There is a need to prepare engineering students to address increasingly complex global challenges. Engineering students have tremendous potential, and given opportunities to develop themselves as leaders, that potential would be increased. The world needs engineers who can balance the opportunities of their organizations with the limits of the planet, engineers who can mobilize others towards a common good, and engineers who can communicate their technical knowledge in ways that empower others. It is apparent that engineers are under-represented in the top leadership posts in politics and the corporate and social sectors. As demonstrated at MIT, Penn State, Tufts and other prestigious American engineering schools, there is a movement to deliver leadership education that empowers engineers to fulfill their goals and have greater impact in the world.

The University of Toronto Engineering Leaders of Tomorrow (LOT) program is the first of its kind in Canada. LOT has successfully engaged students from across all the undergraduate and graduate Engineering programs through curricular courses, co-curricular certificate programs and extensive extra-curricular offerings. LOT began in 2002 in the Department of Chemical Engineering and Applied Chemistry. In 2005-06 there were 39 events in Chemical Engineering and just over 800 student contacts. In 2006 funding was granted by the Provostial Academic Initiative Fund (AIF) and the program was expanded to be offered Faculty-wide. The program has grown tremendously since; in 2008-09, participation reached 8400 student contacts at 199 events. It is worthy of note that LOT has been praised by alumni donors and generously supported by donors who have committed over $2 million towards LOT scholarships, awards, and programming. Now that LOT has been in operation for eight years in Chemical Engineering and four years across the Faculty, the next stage in engineering leadership education at UofT would provide an opportunity to reach more students and have deeper impact. Beginning the next stage calls for a process of reflection and program and curriculum planning.

Leadership learning begins with individuals coming to know themselves, their values, their strengths and weaknesses, their talents and their passions. Self-knowledge increases personal capability, which is further enhanced through the creation of a personal vision of the future, growth in emotional intelligence, and the ability to make decisions that are congruent with personal values. The second level of development involves relational leadership where students grow as collaborators and team members, learn how to effectively communicate, resolve conflict and become astute in team dynamics. This level of skill empowers students to inspire others and to build strong teams and groups. The third level of development is organizational leadership, which manifests itself in organizations of all types, including businesses, institutions, governmental and non-governmental entities. This level of leadership includes creating organizational vision, setting direction, embracing ambiguity, reconciling organizational aspirations and constraints, and empowering others to achieve the vision. The last level of development, societal leadership, involves creating change beyond the organization. Leading in society requires understanding the issues of the day and acting as citizens and catalysts of change. Individuals that participate in political change, contribute to social movements and deeply engage citizens demonstrate societal leadership. Programming at these four levels will enhance engineering education and empower our graduates to contribute at a higher level.

Teaching leadership has special challenges. Some would argue that it cannot be taught, that it must be learned, through experience, and they are not wholly wrong. It cannot be taught by lecture alone; it requires a number of different strategies to engage students in a number of ways: intellectual, social, psychological and emotional, and with a number of formats, such as: experiential workshops, design laboratories, team projects, field excursions, mentoring, coaching, guided reflection, service learning, discussion tutorials, and visioning exercises. Paraphrasing Kolb and Fry, the learning process is a cycle consisting of conceptualization/abstraction moving to active experimentation moving to concrete experience moving to reflective observation and completing the cycle by moving back to conceptualization; the student starts the process at any point in the cycle.

The Task Force recommends the creation of the "Institute for Leadership Education in Engineering" (ILead). The Institute vision statement we propose is: "Engineers leading change to build a better world". The Institute would be the first of its kind in the Canadian engineering landscape, and would position University of Toronto Engineering to lead the way in empowering engineering students to succeed as leaders in their profession and beyond. The Institute would create a recognizable hub for student leadership education activities and programming, and for faculty who seek to teach, and conduct research on, engineering leadership. The Institute would create visibility with funders for supporting engineering leadership education. It would promote the building of resources and recognition of engineering leadership theory and practice at the University of Toronto and beyond. The function of the Institute is threefold: teaching, research and outreach in the realm of engineering leadership development. The Institute would provide focus and resources for a proposed leadership curriculum planning committee. Co-curricular and extra-curricular leadership development activities would continue to be led by the Engineering Leaders of Tomorrow program operating under the umbrella of the Institute. The Institute will facilitate research and scholarly work on leadership pedagogy and engage with others around the world doing this kind of work. There is much to be done in presenting the concepts and the opportunities of engineering leadership education outside the Faculty, to alumni, to the profession more broadly and to engineering schools across the country. UofT Engineering is first in Canada in this field and has much to contribute.

Recommendation and Motion for Faculty Council:

That the Faculty establishes the Institute for Leadership Education in Engineering with the mandate to:

a) Provide and facilitate curricular, co-curricular and extra-curricular leadership development programming.
b) Engage in research on engineering leadership education.
c) Incorporate the ongoing functions of Engineering Leaders of Tomorrow.
d) Be an Extra-Departmental Unit – C (EDU-C) reporting to the Dean.

Task Force Mandate, Membership, and Process

Dean Cristina Amon established the Task Force on Engineering Leadership Education in the Faculty of Applied Science and Engineering in October 2009. The Task Force was to review the advances made by the Engineering Leaders of Tomorrow (LOT) program and develop strategic options for the future.

Mandate

1. To review progress of the development of engineering leadership education at UofT.
2. To review and report on leadership education in engineering at other universities.
3. To recommend structures, processes, and models for advancing engineering leadership education at UofT including: curricular, co-curricular, and extracurricular activities and research.
4. To create a vision for engineering leadership that reaches engineering schools and the engineering profession across the country.

Membership

Doug Reeve, Professor and Chair, Chemical Engineering and Applied Chemistry (Chair)
Shahed Al-Haque, Undergraduate Student
Phil Byer, Professor, Civil Engineering
Dave Colcleugh, Leadership Development Professor, Faculty of Applied Science and Engineering
Bryan Karney, Associate Dean, Cross-Faculty Programs and Professor, Civil Engineering
Chris Langan, Undergraduate Student
Maygan McGuire, Graduate Student
Lisa Romkey, Senior Lecturer, Engineering Science
George Roter, Co-CEO, Engineers Without Borders
Ian Simmie, UofT Student Life Programs
Annie Simpson, Coordinator, Engineering Leaders of Tomorrow
Angela Tran, Graduate Student

Process

The Task Force met thirteen times from the beginning of October 2009 to the middle of April2010, each time for two or three hours. We discussed the mandate, debated the nature of leaders, leading and leadership, crafted strategy and worked to clarify the capabilities and attributes of leader-engineers. In the early investigation phase we requested and received presentations from people engaged in leadership-related activities:

- Engineering Strategies and Practice and First Year Studies - Susan McCahan and Lesley Mak
- Engineering Leaders of Tomorrow (LOT) Graduate Students - LOT:G, Pawel Kosicki
- Engineering Leaders of Tomorrow (LOT) Program – Annie Simpson
- Leadership Development by the Engineers without Borders (EWB) UofT Chapter – Mike Klassen and Mina Shahid
- LOT Undergraduate Cross-Faculty Working Group – Shahed al-Haque, et al.
- The Engineering Society – Wayne Lin and Jimmy Lu
- The MIT Report on Engineering Leadership – Dr. Robin Sacks
- APS 1010 Cognitive and Psychological Foundations of Effective Leadership – Dr. Robin Sacks

- The Engineering Communication Program - Director Peter Weiss
- Engineering Science Praxis Courses– Lisa Romkey

At a later stage we undertook a substantial investigation of student thinking about leadership through five focus groups. We investigated engineering leadership education at other schools in the US and Canada by web research and phone interviews. We formed subcommittees to develop ideas on: leadership education, institutional structure, accreditation criteria, leadership competencies, and student developmental stages. We heard updates on related meetings: the LOT presentation to Governing Council, the LOT presentation to Engineering C&D, and the meeting of the University Leadership Educators Network (ULead).

Final Report of the Task Force on Engineering Leadership Education

1. There is an Urgent Need for Engineering Leadership

The engineering profession in Canada is known and respected for its contributions to society in the development of the nation, through infrastructure (railways, roads, dams, the electric power system), through manufacturing (automobiles, telecommunications, aircraft) and through resource development (the oil sands, forestry, mining). However, society's recognition of this contribution, and indeed the profession's own appreciation of its importance, is not as great as it ought to be. In part, this is due to the failure of engineers to stand up and be counted, to be vigorous and visible participants in the great debates of our society. It often seems that the great strategic decisions of the day are made with little appreciation of technological realities. Engineers share responsibility for the failures of leadership we have witnessed in Canada: the medical isotope failures at AECL, the collapse of GM, the waste of wheat on bioethanol fuel production, the cost overruns at Ontario Hydro, the unsustainable sprawl of suburban Toronto, the hollowing out of Nortel, and the impending environmental disaster of the oil sands development, to name a few. Engineers have expertise in all of these matters, but we have missed opportunities to use it strategically and forcefully. We have failed to live up to our responsibilities.

Engineers have exceptional talent, drive, and training for transforming systems and materials. Engineers have created the Blackberry, the Dash 7 aircraft, the CN Tower, and continue to provide safe food, water, air, and shelter for an increasingly-urbanized global population. Engineers, through technical excellence, identify and analyse problems, design and evaluate solutions, plan and execute new systems. We must join our technical excellence to strategic excellence that takes into account broader economic, environmental, and social issues. Our technical work must be aligned with appropriate strategies for a sustainable future. We must be powerful contributors to the strategies of our companies, governments and institutions. We must hone our skills to be outstanding leaders to advance the success of our teams and organizations.

Engineering education provides technical excellence; this is an essential foundation for engineering leadership. However, beyond science, mathematics, problem solving and design, engineers must work with others, sometimes to lead others and sometimes to follow. To be effective with others, engineers must first know themselves: their values, their beliefs, their ambitions, their strengths and their weaknesses; and they must have the confidence (and the humility) to interact productively with others. To be effective, engineers need to know how teams and small groups function through team formation, loyalty development, team dynamics, conflict resolution, cultural differences, and decision-making. To be effective, engineers need to know how organizations work, how organizational structures are devised and function, how organizations create their own values, beliefs and principles. To be effective, engineers need to understand the needs and dynamics of society, to be aware of the issues of the day, to build on the ethical foundations of the profession, and to always place their work in context. The US National Academy of Engineering put our challenge this way:

"In the past those engineers who mastered the principles of business and management were rewarded with leadership roles. This will be no different in the future. However, with the growing interdependence between technology and the economic and social foundations of modern society, there will be an increasing number of opportunities for engineers to exercise their potential as leaders, not only in business but also in the nonprofit and government sectors. In preparation for this opportunity, engineers must understand the principles of leadership and be able to practice them in growing proportions as their careers advance."

There is a compelling need and a great opportunity to provide engineering students with the knowledge, skills and practice to increase their leadership capability and competence, and by extension, their ability to build a better world. Elevating the capability of graduating engineers through the development of leadership skills will be increasingly noticed by students with ambition and a desire to make a difference; it will attract new talent to the profession, and, in time, elevate the profession.

We have the potential to transform engineering education and the engineering profession by adding leadership excellence to technical excellence. Engineering leadership education is an outstanding opportunity to empower engineers to make *the* difference.

Challenging Beliefs

To begin to progress towards actualizing the opportunities of engineering leadership education, we need to examine beliefs about leadership.

Leadership can be learned. Not everyone believes this; indeed, there are many who scoff at this notion, believing that leaders are born, not made, that leaders have gifts of presence and power and oratory. Even if "leaders" might have genes that start them in the right direction, it is a foolish notion to say that a great leader was born fully formed and did not learn anything from the cradle to the White House. Of course we all have a set of genes that determine some personal characteristics. Some people are blessed with talent, for instance, for playing the cello or athletics - or leadership. But then there is much hard work and dedication to learning; just as Yo-Yo Ma had a gift and then learned to play the cello, and Sidney Crosby had a gift and then learned to play hockey, Barack Obama had a gift and then learned to be a leader. If leadership can be learned - leadership can be taught.

Everyone is responsible for leadership. What does this mean? How can it be possible that one is responsible for the leadership of one's country, one's province, one's city, one's university? Surely it is somebody else's job. Let us put it this way: we are responsible for the leadership we have. Let us consider this on a smaller scale, that of the team. Am I responsible to the leader of the team I am on? Absolutely! She is my leader and I have a responsibility to support her, to challenge her, to encourage her and, when all the talking is done, to follow her. Leaders do not exist without followers, and strong followers create strong leaders. As a team member, I am responsible to step up and be the leader at certain times on certain subjects when I have the insight, the idea that will lead to progress, the passion, if only to say my peace for the moment that counts. Everyone is a leader.

> "Our passion is to liberate the leader within."
> *James Kouszes and Barry Posner*

Leadership begins with self. When we think of leaders we sometimes think of them as sitting high up in tall buildings at the head of legions of employees, or rallying the party in parliament

or commanding the troops and, indeed, those are scenes where leaders operate. Large organizations are impressive and complex, and need leaders. But large organizations are built on small groups and teams; groups are built on individuals; individuals are built on the self. The self is not just about the mental capability of the individual, the intellect, it is also the emotional and social capability, and, for that matter, physical capability (endurance, calmness, alertness) of the individual. If I want to be a better leader I must look inside and be a better person. I must know myself better. Motivation of others begins with self-motivation. If I am not motivated how am I to motivate others? I must know myself well in order to know others well.

> "Becoming a leader is synonymous with becoming yourself. It is precisely that simple, and it is also that difficult."
> *Warren Bennis*

Leadership capability empowers engineering. Engineers are capable people: we can solve complex problems; we can do detailed analysis of processes, systems and structures; and we create impressive designs. But is that enough? Will it solve the challenges we face? When we look around us it seems that the critical decisions that set the course for society are made with little engineering input, and as a consequence, are perhaps flawed. Wheat is used to make ethanol to fuel cars; Ontario will pay eighty cents per kilowatt hour for solar power. Of course there are political and economic factors in decisions like these but is there also sound engineering analysis? One wonders. Engineers are not common in the senior councils of business and are uncommon in government. Engineers are called upon to answer the "how to" questions, and, generally, do not address the "why" and "what" questions. Indeed, we do not step up and address the tough questions and engage in the debates that will determine direction. Leadership is about determining direction and influencing people. It is about values, vision, mission, and strategy, and engineers are too little engaged in leadership.

Leadership skills and competency arising out of these beliefs will increase the contribution of engineers to building a better world: leadership can be learned, everyone is a leader, leadership begins with self, and leadership empowers engineering.

2. Leadership Education

Progress at the University of Toronto – Engineering Leaders of Tomorrow

Engineering Leaders of Tomorrow (LOT) began in 2002 in the Department of Chemical Engineering and Applied Chemistry. In 2006, funding was granted by the Provostial Academic Initiative Fund (AIF) and the program was expanded to be offered Faculty-wide. LOT offers engineering students intentional, structured, and meaningful leadership skills development programming that integrates leadership theory and application. The program is unique in Canada; it integrates leadership development through curricular, co-curricular, and extra-curricular facets of the engineering student experience. In addition to the instructional and experiential elements, the program also uses recognition systems (certificates, awards, and scholarships) to increase the value placed on leadership.

Based on the belief that leadership education will empower engineering graduates to contribute more effectively to positive change and innovation, LOT's vision is: "*An engineering education that is a lifelong foundation for transformational leaders and outstanding citizens.*" Its goal is to provide students with foundation skills related to self-awareness, interpersonal relations, and leadership in teams, organizations and society.

The program has grown tremendously over the last four years. In the year prior to going Faculty-wide there were 39 events in Chemical Engineering and just over 800 student contacts. In the second year of Faculty-wide programming, academic year 2007-08, there were 142 events offered and 4000 student contacts. In 2008-09, participation doubled with over 8000 student contacts at 199 events. LOT aspires to reach every student in some way, either through academic courses, lectures on leadership infused into the curriculum, co-curricular certificate programs, Department-based programs, and workshops for engaged student leaders.

Programming is provided with three levels of engagement. Basic-level programming seeks to provide all students with an appreciation of the value and nature of leadership. Mid-level programming offers students opportunities to learn, develop and then exercise newfound skills. Highly engaged students can pursue their leadership development at an enhanced level. The table below provides examples of program components addressing different levels of student engagement.

Basic-Level	Mid-Level	Enhanced-Level
Infusion Lectures Seminars, Talks, and Panels Discussions and Workshops	Certificate Programs Department Working Groups Summer Programs	Leadership Courses High-intensity Retreats

For students wishing to engage at the enhanced level, LOT offers three academic courses: APS 501 - Leadership and Leading in Groups and Organizations, APS 1010 - The Cognitive and Psychological Foundations of Leadership, and APS 1011 - Concepts and Applications of Authentic Leadership. Feedback from students who have taken these courses has been exceedingly positive and student demand has been greater than we have been able to accommodate.

At the mid-level of engagement, three co-curricular certificate programs are offered. Two of these take place during the academic year and involve five two-hour skill development workshops: Certificate 1 -Team Skills, and Certificate 2 - Self-Leadership: Leading from the Inside Out. The curriculum for both certificates is highly experiential. Assessment and feedback

has shown a high degree of growth in student learning. A third certificate program, offered in the summer (twelve-weeks, one half-day per week) is organized in the Department of Chemical Engineering. Also at the middle level of engagement, students participate in Department/Division working groups. With the support of Department/Division faculty and staff as well as LOT staff, students in each department practice their leadership skills by organizing events (guest lectures, panels, training sessions) and other activities.

Finally, leadership infusion lectures and skill development workshops are designed to reach all undergraduate students. Six lectures are presented within existing courses to students in all years and departments. The intention is that all students will participate in all lectures. Lecture topics include: Engineering Leadership, Developing Personal Potential, Leadership in Teams, Leadership and Vision, Leadership and Citizenship, and Reflection and Growth. Individual leadership workshops and guest speakers are also open to all students. Workshop topics range from conflict resolution, to group facilitation, to emotional intelligence. Guest speakers are drawn from industry, government and the not-for-profit sector.

Various types of assessments have been used to evaluate the effectiveness of programming, and to measure the development of specific leadership competencies in students. These methods have included anonymous feedback forms after events, before and after surveys of participants, evaluations of courses, and student testimonials. These assessments have provided evidence that the students value this learning and that it is enabling impressive personal growth. More generally, the program is affecting a steady shift in culture within the Faculty. Many engineering students are beginning to increasingly value leadership, some are starting to exercise their newfound skills, and a few are now pursuing personal leadership development at an enhanced level.

Engineering Leaders of Tomorrow is at the forefront of engineering leadership education in Canada. The program is starting to expand beyond our Faculty into other parts of the University, and we anticipate even greater impact beyond our Faculty in the coming years. Students who have engaged with the program have recognized the value that it adds to their engineering capability and see LOT as a distinguishing feature of their engineering education.

Progress at the University of Toronto: Team Design (ESP and Praxis), EngSoc and Student Clubs (EWB)

Leadership education is being undertaken in a number ways within the Faculty, in curricular and extra-curricular settings. As part of the Task Force's research, presentations were invited from a number of individuals: Professor Susan McCahan on team projects in *Engineering Strategies and Practice* (APS 111/112), and Lecturer Lisa Romkey on team projects in the Engineering Science Praxis courses. The President and Vice President of the Engineering Society and the Co-Presidents of Engineers Without Borders (EWB) were also invited to share their leadership philosophy and activities.

In APS 111/112 students experience the challenges and satisfactions of working in teams on real-life design projects. Teaching assistants are trained specifically in how to coach teams and support active learning. Professors are offered training as well to support the team process and recognize challenging group dynamics. This highly innovative course recognizes the importance of developing team leadership skills, not just for the assigned team leader but for all group members. By educating students on group dynamics and group roles, teams are empowered to hold each other accountable and practice shared leadership as they complete their projects.

In the Engineering Science Praxis courses, students are encouraged to develop their own design philosophy. Students learn design theory and terminology and engage in team projects where they frame a problem, first on campus and then in the city, applying principles of sustainability, accessibility and usability. Students are supported by the instructional team. They integrate theory and practice, identify new problems, defend their design decisions and explore the ways in which people are affected by technology.

Engineering students are known for their engagement in extra-curricular activities. Student leaders are at the heart of all the extraordinary activity that goes on outside the classroom in clubs and teams. Through this work, students grow in confidence, empower others, and influence positive change. The Engineering Society (EngSoc) provides training for orientation leaders and executive team members and offers a forum for club leaders and their executive teams to develop and practice leadership. EngSoc's approach is based on applied leadership. EngSoc executives write a reflective transition report at the end of their terms. EWB offers impressive leadership development training to their executive team, directors and members. This training strengthens the impact of EWB participants by encouraging self-awareness and reflection, leadership practice, and active engagement with the community at large.

There are many existing courses and structures within the Faculty that emphasize team project work, a perfect laboratory for greater leadership education. There is also tremendous potential in the ongoing support of leadership skills development for student leaders in clubs and teams.

Leadership Education at the University of Toronto

Engineering Leaders of Tomorrow is the most comprehensive and extensive leadership development program at the University of Toronto with curricular, co-curricular, and extra-curricular programming tailored specifically for engineering students, and is seen by many at the University as a model for leadership programming. Parenthetically, Engineering LOT students were invited to share their experience in a brief address to Governing Council in December of 2009. One of the mandates of the original AIF funding was that lessons learned in engineering be shared across the University and, in that spirit, beginning two years ago, the LOT team formed, and has since led, a University-wide discussion group of leadership educators. We have gathered to share best practices and build a community of educators committed to supporting the full development of students as leaders. The group has been formalized as The University Leadership Educators Network (ULead) and presently includes faculty and staff from OISE, Rotman, Physical Education, Scarborough Management, Medicine, School of Public Policy and Governance, the Office of Student Life (both central and Scarborough), and Engineering.

This University-wide effort led to the first Summer Institute on Leadership Education in June 2009, a full day event with 60 participants co-sponsored by the Office of Teaching Advancement. The day included a personal development workshop in the morning and a best practice session and leadership panel in the afternoon. Planning for the 2010 Summer Institute is currently underway. Also, leadership was added as one of the three themes at the University's annual Teaching and Learning Symposium organized by the Centre for Teaching Support & Innovation. We believe that many of the components of our program will be easily transferred to other programs; indeed, the School of Public Policy and Governance has already expressed interest in one of the leadership courses. Through the formation of ULead, Engineering has come to be recognized as being at the forefront of leadership education at the University of Toronto.

Leadership Education at Other Engineering Schools

As part of our fact-finding process, members of the Task Force did website research on six engineering leadership programs in the United States and Canada and then conducted telephone interviews with directors/leaders of those programs. The need for leader-engineers is recognized at highly respected schools in the US such as MIT, Tufts, Penn State, and RPI. Although leadership skills development is common in US business schools and fairly widespread in universities, so far, there are not many programs specific to US engineering schools. However, it is apparent that leadership education in US engineering schools is on the rise and certainly MIT has made its mission clear on the website of its Gordon-MIT Engineering Leadership Program: "To increase the focus of national engineering education on the development of leaders of engineering invention, innovation and implementation." We also spoke with the University of Calgary about their leadership program for engineering. An early guide to our research was a white paper commissioned by MIT that made a survey and assessment of engineering leadership education across the world, including our own Leaders of Tomorrow.

It is also noteworthy that donors have recently been inspired to generously support these university-based engineering leadership programs: MIT, $20 million; Tufts, $40 million; RPI, $1 million, Calgary, $1 million; and, just recently, Rice, $15 million.

We also did some research on leadership training in military academies. We spoke with the Royal Military College (RMC) staff in the Department of Military Psychology and Leadership, and with the Dean of Engineering, and we have an introduction to the Toronto-based Canadian Forces College, whose mission is stated on their website: "We educate leaders about war, peace, and security." There is also extensive leadership development training at the US military academies; for example, the following is the stated purpose of the US Air Force Academy found on their website: "We teach, study, and apply the behavioural sciences and leadership to develop leader-scholars for service to the nation."

Our research and conversations informed us of a number of excellent practices and opened channels for further collaboration; we were invited to visit the schools with whom we talked and to participate in an upcoming conference. We were deeply impressed by the vigour and enthusiasm with which leadership skills development is being undertaken in these schools—there is excitement in the air. We also came to understand how our own approaches were similar, on the one hand, and distinctive on the other; we have only been at work on this for a short while but we have accomplished much about which we can be proud.

3. Capability and Competency

Engineering competencies are defined with some precision by professional accreditation processes, and, more recently, in Ontario, by degree level expectations. Leadership competencies, on the other hand, have a much wider range of understanding and definition. Nonetheless, engineers have competencies and behaviours that we also find in leaders, for instance: communication skills, team skills, the application of ethics, understanding the context of their work, an appreciation of risk and change, and commitment to life-long learning. However, what are the differences between the competencies and behaviors of engineers and of leaders? What are the characteristics of the leader-engineer"?

Engineering Capability and Competency

The University of Toronto, at the direction of the Ontario government, has undertaken to articulate "Undergraduate Degree Level Expectations" (UDLEs). In 2008, the Faculty defined the UDLEs for those receiving the Bachelor of Applied Science, engineering graduates (Faculty). Accordingly, the UDLEs for engineering graduates give the overall learning objective as: "…an education that will allow them to be leaders in society in developing solutions to its most pressing problems" (Ibid.). There is a clear and explicit expectation that engineering graduates develop the capability to be "leaders in society."

The UofT engineering UDLEs describe six categories of expectations: 1. Depth and Breadth of Knowledge; 2. Knowledge of Methodologies; 3. Application of Knowledge; 4. Communication Skills; 5. Awareness of Limits of Knowledge; and 6. Autonomy and Professional Capacity. Most of these expectations, when examined in detail, refer to engineering/technical competency, and given the bold assertion that graduates be "leaders in society" it seems that the articulation of leadership competencies is somewhat lacking in the UDLEs. It is recommended that the degree level expectations for engineers be revisited with a view to correcting this deficiency.

The Canadian Engineering Accreditation Board also defines graduate attributes for engineers (CEAB). Most of these attributes refer to engineering/technical competency. Several of the attributes of the graduating engineer also describe attributes of leaders or leader-engineers.

In the United States, ABET defines the outcomes necessary for engineering programs to be accredited ("Criteria for accrediting engineering programs"). As with Canadian accreditation there is a natural predominance of engineering/technical competencies. Broadly speaking, the required competencies of engineers that are also competencies of leaders include communications, teamwork, ethics, understanding the context of work, and life-long learning.

In summary, as stated at the outset, engineering programs seek to graduate engineers that have skills, competencies and behaviours that we also find in leaders. Our next step is to consider in more detail the competencies of leaders so that we can discern differences and can develop an understanding of the leader-engineer.

Leadership Capability and Competency

Leadership is a process, not a position. The leader in the context of process is not the boss; rather, the leader is the one who makes things happen, who leads the way forward with vision and passion, and who inspires others to join in the mission.

Authorities on leadership now espouse a collaborative approach to leadership, as opposed to one based on power and authority. Leadership for the purpose of transforming our students, our institution, and our society needs to be viewed as a process whereby individuals work collaboratively in order to foster change and transformation. Susan Komives is among the leading authorities on leadership development among college students. She puts it this way: "Leadership is a relational and ethical process of people together attempting to accomplish positive change" (Komives et al.).

Leaders are not necessarily those that hold formal positions; on the contrary, all people should be considered as potential leaders where they work collaboratively in a group or collective process to effect change. All participants are active shapers of their world. This paradigm of leadership allows for different conceptualizations of power, relationships, values and processes oriented towards more relational definitions of leadership, such as those focusing on systems, influence, and relationships and moves away from viewing leadership as structured, hierarchical, and unidirectional. The capacity to lead is rooted in virtually any individual and in every community. Leaders are developed through increased understanding of their obligations for, and acceptance of, the responsibility to serve one's community and society.

There are innumerable definitions of leadership and characterizations of leaders. Our deliberations have led us to identify the following leadership characteristics desirable in the future engineer. She or he:

a) Is able to vision from a grounding in personal and organizational values.
b) Is practiced at translating personal passions into purposeful action.
c) Is skilled at communicating with, and working in, diverse teams, groups, and organizations.
d) Recognizes that effective leadership extends from a grounding in understanding self.
e) Connects the practice of leadership to positive social change.
f) Is focused on interpersonal relations.
g) Is able to make principle-based/ethical decisions with a tolerance for ambiguity and risk.

When these characteristics are fully realized and coupled with engineering competency, a new engineering identity emerges, that of the "leader-engineer."

The Task Force has articulated four realms of leadership learning: 1) Self Leadership, 2) Relational Leadership, 3) Organizational Leadership and 4) Societal Leadership. They are now discussed in turn.

Self Leadership

One of the most important and fundamental distinguishing characteristics of the leader is awareness of self. Self-awareness goes hand in hand with personal integrity, said another way, personal mastery. In order to inspire others we must first achieve a level of personal mastery that combines self-awareness and personal integrity and empowers not only ourselves but also others. Self-leadership embraces a new set of competencies, beyond those expected of an engineer upon graduation, beyond the skills that would be taught in the traditional engineering curriculum. Whereas every individual has some level of self-awareness, the opportunity is to be deliberate and systematic in development of this particular capability and fully realize the potential of the engineer. The leader-engineer will have highly developed Self Leadership capabilities and attributes.

Relational Leadership

Engineers are expected to have team skills, to be able to work in teams, and to lead a team. Engineering curricula provide some teaching about team skills and opportunities to learn through practice. However, the leader-engineer would have highly developed relational/interpersonal skills that would take all collaborative work, including teamwork, to a new level.

Organizational Leadership

Creating a vision for the future is a skill; it is what differentiates leadership from everything else. A vision is a description of the future that comes from the imagination.
For an organization a vision is the shared understanding of the desired future state; it is the answer to the questions: "What will the organization become?" and "What will the community become?" A vision starts with the inspiration of the leader, imagining the future and what is intrinsically important to him/her.

Societal Leadership

Citizenship applies not just to the country but also to our society, our city, our neighbourhood; being a good citizen is about doing the right thing. Citizenship skills begin with a vision of society, the future state to which we aspire. Citizenship is rooted in the personal motivation to make a difference in society. Vision and citizenship are both rooted in personal values and passions; one must know one's values and passions and be committed to them in order to project them into the future for an organization or for society.

As stipulated by our degree level expectations, engineers are to graduate with an appreciation of the societal and even global implications of their work and the understanding that their first duty is to society. In truth, many engineering students hear of their "first duty to society" when they arrive in first year and then again when they graduate; it could be argued that we only pay lip service to this notion. Committed leadership requires greater appreciation than this and greater knowledge and capability. Creating a vision, for oneself, for an organization, or for society is a competence that empowers great leadership and great citizenship, and enables and enhances great engineering.

In summary, there are core competencies of the engineer—mathematics, science, problem analysis, design and other technical skills—that are essential for the practice of engineering and these are supplemented by supporting competencies: communication skills, team skills, understanding of professional responsibilities, ethics, economics, and impact on the environment and society. Leadership development of engineering students moves the supporting competencies to a significantly higher level of performance and creates new understanding and capability. The leader-engineer has a powerful toolset with which to build a better world.

To engage the engineering student in development of leadership skills is to enable and empower the future engineer to even greater achievements.

4. Objectives, Processes and Format for Engineering Leadership Education at UofT

Simply said, the objectives of engineering leadership education should be to create circumstances for the development of the four leadership capabilities and competencies of the engineer as described in the previous section: Self, Relational, Organizational, and Societal Leading. Starting from these desired competencies, specific learning outcomes can be devised. The Council for the Advancement of Standards in Higher Education said it this way: "Leadership is an inherently relational process of working with others to accomplish a goal or to promote change." ("The Role of Student Leadership Programs"). Most leadership programs seek to empower students to enhance their self-efficacy as leaders and understand how they can make a difference, whether as positional leaders or active participants in a group or community process. The Council goes on to state that:

> "Leadership development involves self-awareness, understanding of others, personal congruency, valuing of diverse perspectives, organizational skills and comfort with change. Leadership also requires competence in establishing purpose, working collaboratively, and managing conflict." (Ibid.)

Teaching leadership has special challenges. Some would argue that it cannot be taught, that it must be learned, through experience; they are not wholly wrong. It cannot be taught by lecture alone, but requires a number of different strategies to engage students in a number of ways—intellectual, social, psychological and emotional—and with a number of formats, such as experiential workshops, design laboratories, team projects, field excursions, mentoring, coaching, guided reflection, service learning, discussion tutorials, and visioning exercises. Paraphrasing Kolb and Fry, the learning process is a cycle consisting of conceptualization/abstraction moving to active experimentation moving to concrete experience moving to reflective observation and completing the cycle by moving back to conceptualization; the student starts the process at any point in the cycle.

To deepen our understanding of student awareness of, and readiness for, the concepts of engineering leadership education we commissioned a series of five focus groups involving about fifty students, undergraduates and graduate students. Four of the focus groups were for students who had not been engaged in LOT. Those students said they identified as "engineers" rather than as "leaders." They felt there was a negative connotation to the words "leader" and "leadership." They indicated that leadership should be a choice and was not for everyone. Students thought that, given the very full engineering program, adding extra leadership material would be difficult and so leadership learning should be integrated explicitly into the curriculum where opportunities existed. The response from students who had been exposed to LOT programming was different. They indicated that engagement with LOT programming and leadership-related courses had a positive impact on their self-perception as leaders and broadened their understanding of what leadership represents. These students also started to view themselves as agents who can influence society.

One of the most exciting developments in the area of student leadership development assessment is the Multi-Institutional Study of Leadership (MSL), of which over 100 schools in the US, Canada, and Mexico have participated, representing a significant contribution to this area of inquiry. Last year, LOT, in partnership with the UofT Office of Student Life, participated in the MSL 2009. The University of Toronto became the first Canadian university to be part of this highly regarded study, and had a 40% response rate – one of the highest among the 103

participating institutions. Eighteen hundred UofT engineering students responded to the survey. The results show that UofT engineering students expect to make a positive impact on society as a leader after graduation: 35% to a great extent and 50% to a moderate extent. Ninety percent of students expect to make a positive contribution as a leader in their career; fifty percent expect to make a positive contribution in their community.

We recognize that engineering students have different levels of interest in leadership learning ranging from none to very high. As described above, LOT's strategy to date has been to provide a range of programming that matches the student's level of interest. For all students LOT offers Basic-Level offerings (infusion lectures, seminars, talks, panel discussions and workshops); for many students LOT offers the Mid-Level (certificate programs, department working groups and summer programs); and for the few, LOT offers the Enhanced-Level (leadership courses and high-intensity retreats).

Another important dimension is the form of programming offered: curricular, co-curricular, and extra-curricular. We recognize that the development of leader-engineers will best be served by programming in all three realms.

The LOT program is continuously expanding its methodology for evaluating its influence on the development of both individuals and cohorts of students. Assessments have been conducted for the certificate programs, the curriculum infusion initiative, the leadership courses, and departmental summer programs. Initial assessments have found an increased understanding of the nature of leadership and development of specific leadership competencies. The student evaluations of APS 501 and APS 1010 have been exceptional, well above Faculty averages on many parameters. An overall measure of the program's success is its phenomenal growth. Another measure of success is to be found in compelling personal stories in provided by students who have been engaged with LOT's programs. One can read testimonials from students on LOT's website at: www.lot.engineering.utoronto.ca and access the link "Student Testimonials."

Now that LOT has been in operation for eight years in Chemical Engineering and four years across the Faculty, there is a next stage in engineering leadership education at UofT that provides an opportunity to reach more students and have deeper impact. A generous donation will permit expansion of staff for developing, delivering and monitoring programming. Beginning the next stage calls for a process of reflection and program and curriculum planning. Some of the concepts for discussion, and potentially for development, are presented below.

Curriculum Concepts

Specialist Leadership and Design Instructors

Specialist Leadership Instructors would work with engineering design course instructors (ultimately across the Faculty and across all years) to help shape curriculum, provide instruction, and aid in guidance and mentoring of teams and team leaders. This would provide a teaching resource for all team-based learning.

Leadership Infusion Lectures

Leadership concepts would be presented in lectures to all programs each term providing one hour of exposure to every student every term. Focus would be on first and second year students to establish fundamental concepts and awaken interest. The LOT pilot lectures have been well received to date.

The Undergraduate Certificate - Concepts of Leadership and Leading

Four academic courses would be required to obtain the certificate. Courses offered at the 500-level would be provided to both undergraduate and graduate students. A Leadership (and Engineering Practice) Minor is an interesting future prospect. (See Penn State website.)

The Post-Graduate Certificate – ELITE

We can envision expansion of courses available on leadership and leading, for instance, courses offered at the 500- and 1000-level, and perhaps specialized, higher-level courses for engineers with industrial experience. A course on Research Leadership for those targeting a research career (and for newly appointed professors) is another interesting prospect.

Engineering Leadership Laboratory

The Engineering Leadership Laboratory would provide hands-on projects, team actions, and simulations with guided reflection in weekly two-hour lab sessions. Potentially, senior students would provide leadership to junior students. (See MIT website.)

Co-curricular Concepts

Experiential Leadership Certificates

Experiential Leadership Certificates would be based on participatory, experiential, two-hour workshops in a series of five related to a central theme. LOT currently offers two such series at the undergraduate level: Self Leadership and Team Leadership. At a minimum, two more should be added, Organizational Leadership and Global Issues and Leadership, although one could easily imagine a number of worthy subjects. Present resource constraints limit the availability to one section per year which is not sufficient to meet demand. Given present and anticipated demand we could easily fill multiple sections with offerings in the fall and spring terms and offerings to post-graduates. Co-curricular certificates would be registered on transcripts.

Leadership Intensives

Leaders of Tomorrow: Graduate (LOT:G), the graduate student arm of the LOT Program, last year organized three one-day intensives that were highly successful. Co-curricular formalization would be a logical next step: a future prospect, undergraduate-focused Leadership Intensives in the summer.

Extra-curricular Concepts

Engineering Leaders of Tomorrow Working Groups and Events

LOT staff are actively engaged in student working groups, supporting and empowering students at the undergraduate and graduate level to undertake leadership roles in creating and executing a wide range of events in support of student development. LOT staff also plan and execute many leadership development events. There are many opportunities for serving our students better through expanded offerings.

Leadership Practice Portfolio

A Leadership Practice Portfolio would contain written reflections on lessons learned from active leadership roles such as society or club executive responsibility, service learning in the community, international service, LOT working group participation.

The Co-curricular Record

The Co-curricular Record is a systematic and authenticated record of extra-curricular activities that becomes part of a student transcript. (See University of Calgary website).

Research and Scholarly Work on Engineering Leadership Education

An important mission for this initiative is to be at the leading edge of pedagogy for the field, to undertake scholarly creation of new knowledge, to participate in scholarly publications and fora, and to continuously evaluate progress in leadership development at the levels of individual, workshop, course, and program. It is recommended that for the next stage, a Leadership Curriculum Planning Committee, reporting to the Faculty Curriculum Committee, be created.

5. Institutional Function and Structure

Leadership development activity in engineering schools elsewhere and in the Faculty is surging ahead, propelled by student interest, society need and the recognition that the engineering profession can, and should, play a greater role in the many challenges confronting society. Establishing an institutional structure that will support and encourage continued rapid growth is recommended.

The Task Force has debated the function, the structure and the name of this unit for engineering leadership education. The Task Force recommends the creation of the "Institute for Leadership Education in Engineering" with the acronym, "ILead." The Institute's vision statement we propose is: "Engineers leading change to build a better world".

The function of the Institute is threefold: teaching, research and outreach in the realm of engineering leadership development. Ideas for teaching in curricular, co-curricular and extra-curricular activities were articulated in the previous section. The Institute will provide focus and resources for a proposed leadership curriculum planning committee. Co-curricular and extra-curricular leadership development activities will continue to be led by the Engineering Leaders of Tomorrow program operating under the umbrella of the Institute. The Institute will facilitate research and scholarly work on leadership pedagogy and engage with others around the world doing this kind of work. There is much to be done in presenting the concepts and the opportunities of engineering leadership education outside the Faculty, to alumni, to the profession more broadly and to engineering schools across the country. UofT Engineering is first in Canada in this field and has much to contribute. However, there is also work to do within the Faculty to demonstrate the tremendous value of empowering technical competence with leadership competence.

It is recommended that the Institute be constituted as an Extra-Departmental Unit - C (EDU – C). The Institute would have a Director reporting to the Dean. An Academic Oversight Committee would consist of the Dean, Vice Dean Undergraduate, Vice Dean Graduate, Associate Dean Cross-Disciplinary Programs, and Assistant Vice-President - Student Affairs. The Director would be an engineering professor appointed part-time to the directorship. The Director would be supported by an Associate Director. There would be an Assistant Director (a staff member responsible for LOT programming). Currently, Professors Doug Reeve and Greg Evans are Co-Leaders of LOT and Annie Simpson is responsible for program development and delivery for, and management of, LOT.

Institute staffing would be responsive to student demand and resources. The Institute would be responsible for identifying and cultivating competent instructors such as: the Leadership Development Professor(s), Associated Faculty Members (Cross-appointed), Lecturers, Program Delivery Specialists, Contract Lecturers and Contract Workshop Instructors. Currently, Dr. David Colcleugh is the Leadership Development Professor for the Faculty and teaches APS 501; three sectional lecturers deliver APS 1010 and 1011; one contract instructor delivers one of the certificate programs and LOT is in the process of hiring a Program Delivery Specialist for co-curricular and extra-curricular programming. Administrative staffing would also be adjusted according to demand and resources; at the moment LOT has 1.25 FTE Program Assistants. It should be noted that LOT has had a history of engaging work-study students and summer student interns.

LOT currently occupies office space in the Wallberg building, WB 239 and 240. This is expected to be a sufficient space for the Institute for the moment but by mid-2011 new space or significant renovations may be required.

LOT has had an operating budget of $200,000 per year since the Provostial award from the Academic Initiatives Fund (AIF) in 2006. A generous donation from an alumnus and his spouse in June 2009 will provide additional program funding over ten years. From 2005, Departmental-level LOT programming in Chemical Engineering has been supported by a donation of $25,000 (2005 dollars); this funding has been committed for a ten-year period.

The Institute presents an outstanding opportunity to link with alumni and with industry. It is expected that donor prospects, having been successful leaders themselves, will find engineering leadership education very attractive. Industry, government and NGO leaders could also be engaged as advisors to the Institute and mentors to students, perhaps through an advisory board.

Postscript

The members of the Task Force are grateful to the many individuals who provided input to their discussions and inquiries. We look forward to the further evolution of engineering leadership education and to its growing empowerment of engineers and the engineering profession.

Please direct any inquiries or comments to lot.engineering@utoronto.ca.

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