

# Leadership Development through Global Engineering Design Course - Praxis III

## University of Toronto

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### Abstract

Praxis III at the University of Toronto is centered on addressing globally situated problems (i.e., real problems faced by members of global communities), and enhancing the leadership and management competencies of engineering students in their second year of study.

### Program Description

Inspired by global competence development in global virtual team projects [1], the first instance of Praxis III in Fall 2021 offered students experience in virtual teaming, thereby enabling students to work with international business peers from a non-Canadian University on globally situated problems. This change was part of a curriculum redesign of the Engineering Science 2-year design sequence, which aimed to improve alignment between existing design courses in the program and expand students' technical knowledge and professional skill set for work in a global context. The current iteration of the course enables students to build leadership and management skills by working on ongoing global, multidisciplinary engineering design efforts, and allows them to tackle real world design challenges with global significance.

For context, Praxis III is a mandatory second year, single semester course in the Engineering Science program at the University of Toronto. The Engineering Science program is structured in "2+2" curriculum sequence consisting of 1) a 2-year foundation curriculum that exposes students to a set of common core courses, and 2) a 2-year specialization curriculum that enables students to focus on one of the eight majors.

Praxis III is the third course in the Praxis (Engineering Design) series, with students taking Praxis I and II in the first year and Praxis III in the second year of the foundation curriculum. While Praxis I and II encourages students to apply foundational engineering leadership concepts in teamwork

settings and to projects in their local communities, Praxis III challenges students to apply engineering leadership in more complex globally situated project contexts.

The Praxis III course was developed following discussions with various stakeholders from the University of Toronto's Division of Engineering Science, Center for Global Engineering (CGEN), institute for Studies in Transdisciplinary Engineering Education and Practice (ISTEP) and the Troost Institute for Leadership Education in Engineering (Troost ILead). The intent was to increase connections to, and focus on, lifelong leadership development and the mission of building engineers prepared for working on global challenges. Praxis III's comprehensive curriculum development effort involved representatives from the Ontario Institute of Studies in Education (OISE) and the International Virtual Engineering Students Team (InVEST) program, both at University of Toronto. This informed the use of six pedagogical practices namely experiential learning [2], scaffolding [3], reflective practice [4], human-centred design [5] and learning communities [6].

To date, four cohorts (including one underway at the time of writing) have completed the course. There were about 200 students enrolled in the first course offering in the Fall 2021, and student enrolment in subsequent course offerings have ranged between 240 to 300 students. Most participating students are second year Engineering Science students, though due to the COVID-19 pandemic some students have also completed the course in their third year of study. Praxis III received a Global Classroom grant in 2021/22 to support the virtual teaming component. Some participating students had the opportunity to engage in a multidisciplinary collaboration with global peer consultants from an international business department at Georgia State University, USA. In another instance, and ongoing during the current iteration, students collaborate with peers from the University of Toronto's Institute for Studies in the History and Philosophy of Science and Technology (IHPST).

The University of Toronto's Praxis III course is uniquely structured to provide students with an opportunity to apply project management practices and demonstrate engineering leadership within authentic, globally oriented engineering design experiences that can help prepare them for a globalized workforce. We provide tools for students to integrate their prior learning both in previous technical and engineering design courses, and courses which discuss the role of engineering in society and vice-versa. Though it is challenging to introduce these topics in a large, mandatory, single-semester course, it also offers an important opportunity to empower students to take the first step towards solving challenging engineering problems with a balance of confidence and humility.

Following ongoing evaluation of our initial offerings, Praxis III continues to evolve to support students in developing leadership competencies for complex, collaborative projects that are focused on global impact. Some of the projects that students have worked on have investigated: a) waste management, plastic and e-waste recycling and re-use for a circular economy in Accra, Ghana, b) improvements to energy use monitoring and micro-generation potential across the African continent, and c) economic viability and work-related health concerns for traditional crafting in Northern Thailand. These projects are built through interactions with global partners and have evolved from year to year. Integral to their project work, students are also challenged to design and build a physical prototype that demonstrates, communicates or helps to de-risk one of the design concepts they have developed. To support this, the course offers instruction in light fabrication methods alongside project management and engineering design learning.

### **Connecting Themes**

In Praxis III, engineering leadership is defined as the ability to apply leadership skills [7] and management skills [8] to effect change within a domain of influence [9]. Based on the transformational leadership model [8], the course incorporates management characteristics focused on administration and performance with leadership skills of social judgement, problem solving, and knowledge [7] via the use of pedagogical tools such as team charters, project roles, team management artefacts and peer review exercises. Building on the concept of leadership as a relational process, the course utilizes the scaffolding of project management methods and tools [10] to support students' technical design process and promote intentional teamwork practices. This approach encourages students to utilize project roles to take ownership of relational and cognitive tasks, and to employ inclusive and transparent work practices that can support the development of core leadership competencies. From the onset, the Praxis III Core Team has incorporated engineering leadership skills development through its focus on teaching design as a humanistic process, using project management principles to support teamwork, fostering sustainability in the design work, and promoting equitable engagement in the course.

### **Instructional Strategies and Teamwork**

Building on the adult learning theory, Praxis III emphasizes real-world challenges, inclusive teamwork, stakeholder involvement, reflective practice, and tangible student outcomes to promote students' leadership development and identities [11]. We prioritize communication and collaborative optimization [12] while promoting technical skill building. Furthermore, students are encouraged to think critically while applying culturally responsive approaches to problem solving within the space of environmental, economic, and/or social sustainability.

Pedagogical approaches for engineering leadership development have included inventories, self-reflections, and team reflections that aimed to facilitate students' deeper understanding of self [13]. At the beginning of the course, students completed the Myers–Briggs Type Indicator (MBTI) assessment to help increase their self-awareness along Myers and Briggs' four dimensions of personality type [14]. The results were also utilized as inputs into the students' team formation algorithm. While at the midpoint and end of the course, the Team-effectiveness Learning System (TELS) inventory survey from Troost ILead encouraged students to provide quantitative and open-ended feedback to teammates on organizational, relational, and communication-based leadership competencies [15]. The students also completed self- and team reflection exercises at the beginning, mid-point and end of the course. These reflections allowed students to describe, analyze, and critically consider new knowledge and team experiences in relation to their self-aware engineering leadership development [16]. They also enabled students to unpack their practice and positionality as engineering designers to integrate their understandings of learning, experience, and purpose of engineering design.

The course strives to support effective teamwork practices by encouraging student teams to establish collaboration structures [17] to enhance productivity, engage in relationship building to build connections and improve trust management [18] and to implement the use of project team management artefacts for efficient time management [10]. Team working structures are established via team charters, including project roles, and protocols for team communication, conflict management and decision-making. Trust and relationship management in teams was fostered via support systems for inclusivity and accountability such as the responsibility matrix, team building ice breakers/activities, and action items trackers. Furthermore, team management artefacts such as project schedule(s), task list(s), meeting notes, and procurement and budget tracker(s) supported students' efficient time management practices.

### **Equity, Diversity, and Inclusion (EDI)**

Sustainability and equitable engagement were at the core of design work through the inclusion of sustainability focused projects, a partnership with a campus makerspace to offer reusable tools, materials, and electronics at no cost, and the provision of baseline prototyping training for students to establish common ground for technical work. These strategies aimed to promote the reduction of our local/environmental footprint through reusable resources, minimize the cost burden on students as well as bridge the gap and the impact of the level of design and prototyping knowledge/experiences coming into the course.

## Our Impact

Peer reflection, self-assessment, and team reflection form an important part of the engineering project leadership evaluation, with emphasis placed on documentation and learning from the human centered design process.

## Next Steps

The Praxis III Core Team plans to continue to explore the involvement of more non-engineering peers in the course to enhance multidisciplinary collaboration and extend impact within other disciplines. They are currently running a pilot with the Institute for the History and Philosophy of Science and Engineering (IHPST), where IHPST students join teams in Praxis III for the first phase of their design project. The Core Team plans to disseminate their work on Praxis III more broadly to allow others to adopt these approaches even in large, single-semester required courses.

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