Environmental Engineering and Sustainability Leadership The University of British Columbia (UBC)

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Abstract

Recognizing the complex societal challenges facing engineers of the next generation, engineering education has an opportunity for transformative interventions in training change agents who can navigate complexity and lead systemic changes. One such initiative is the Environmental Engineering and Sustainability Leadership course offered in the Department of Chemical and Biological Engineering at the University of British Columbia.

Program Description

The Environmental Engineering and Sustainability Leadership course started as a graduate course in 2012. In 2023, it was converted to a fourth-year undergraduate technical elective. It incorporates reflection, leadership, sustainability engineering, teamwork, systems approaches, and design thinking, with technical components of system dynamics modelling and life cycle analysis.

The initial motivation behind the graduate course was to explore the gap between engineering solutions and societal change in envisioning a sustainable future through cultivating leadership skills. In re-designing as an undergraduate course, the motivation was to provide students with complimentary professional skills which are strong determinants of career success. In its first offering as an undergraduate technical elective, there are 11 registered third- and fourth-year students.

This course stands out as it combines a fourth-year course with a second-year lab course, allowing students to apply technical concepts in environmental engineering while exercising leadership skills. The second-year course is a core course taken by the entire cohort (~110 students) and has recently been adapted to incorporate themes around process safety, complexity, and systems thinking. The second year, junior student teams research a case of industrial pollution exposure, conduct a causal loop analysis of the underlying factors, and present their findings in a scientific poster. The fourth year, senior students act as mentors, exercising their knowledge of systems approaches, and leadership skills. Each mentor works

with one or two of the junior student teams, with four or five students per team. The fourth-year course consists of half technical components including system dynamics modelling and life cycle analysis, and the other half of acquiring leadership theory and practice in class.

The collaborative learning between junior and senior undergraduate students through mentorship is also reflective of how the instructors have come to work together. In fact, Dr. Chintalapati was a student in the graduate version of the leadership course over 8 years ago, and is now a junior faculty in the same department. The authors have been intentional in bringing collaborative learning together and mentoring as junior and senior faculty members.

Connecting Themes

Engineering leadership in this case uses frameworks developed for servant leadership to support the mentorship aspects [1], and adaptive leadership [2] which is suitable in dealing with complex challenges. The structure of this collaborative learning is such that the senior students are facilitating the learning of junior students in their understanding of complex systems through causal loop diagrams. In the fourth-year course, senior students develop a deeper understanding of systems analysis, graduating from causal loops to quantitative system dynamics modelling. This experience, paired with their leadership training, enables them to support the junior students in recognizing, within their respective case studies, the key factors and interactions that ultimately are resulting in pollution exposure. Senior students, employing servant and adaptive leadership practices, apply professional skills acquired in the leadership course and others, concurrent with capstone design in their final term. They navigate emergent challenges while working with junior students, thereby exemplifying these skills for the students they are supporting.

Instructional Strategies and Teamwork

Collaborative pedagogy is applied for our courses as it is intended for mutual learning to emerge. Building connections between the fourth and second year courses is part of a larger intention to develop a holistic, longitudinal learning experience in the areas of systems modelling for complex challenges across the program. By the time senior students take the leadership course, they have been introduced to systems thinking in a first-year engineering course, followed by the second-year course described in this case study. In third year, students learn about leadership and professional development in their lab courses, and systems analysis in a Sustainable Engineering course, leading to the fourth-year course described in this case study. By looking at a complex issue where there is ambiguity, uncertainty, and multiple perspectives, senior students are challenged to draw on various qualities under servant leadership such as listening, empathy, reflection, trust, reflexivity, community building, humility and awareness (taught in the

leadership course) as they exercise their leadership with the junior students and enable emergent learning.

While junior students learn primarily through team-based activities and deliverables, senior students work in teams through other technical assignments. Based on the collaborative pedagogy, there is a diverse dimension to the team-based learning. Collective in-class reflection allows the senior students to support each other. This is an intentional part of building the learning community among senior students through the course. A facilitator visits both second- and fourth-year courses to discuss team dynamics, building a common language for both senior students as mentors and junior students working in teams.

Equity, Diversity, and Inclusion (EDI)

The junior students are introduced to the disproportional exposure of pollution in marginalized communities through a lens of process safety and systems analysis. The goal is for junior students, through their causal loop diagrams, to recognize the systemic factors that lead to environmental racism, highlighting how efforts towards equity, diversity and inclusivity are essential in chemical engineering practice. While mentoring the junior students, it is expected that the senior students are also understanding the context and complex issue at hand.

Our Impact

The senior students are assessed on leadership skills through goal and vision setting, soliciting feedback and reflecting on the mentoring experience. They are also assessed on a reflective journal, facilitating a class activity on a chosen leadership quality, and a final oral interview (in place of a written exam). The technical aspects are assessed through two assignments on systems analysis using Vensim, and a life cycle analysis applying GHGenius software.

Next Steps

Our aspirations for the future include students to gain experience in systems approaches through their academic education and make deeper connections between the scaffolded activities addressing systems approaches from various courses. Ultimately, we hope to have the fourth-year course enable a continuation of systems approaches introduced in the second-year course. Simultaneously, the junior students are taught the concept of followership, the counterbalance to leadership, which requires active engagement, critical thinking (rather than blind compliance), adaptability, effective communication, initiative and accountability. We aim to establish a foundation of leadership qualities for junior students by creating an intentional and defined role for mentees, requiring active participation in a collaborative process towards common goals. This may not only prepare them to take on mentorship roles as seniors but also

foster a deeper understanding of complex systems modeling, contributing to their development as leaders.

References

[1] S. Norris, S. Sitton, and M. Baker, "Mentorship through the lens of servant leadership: the Importance of accountability and empowerment", *NACTA Journal*, vol. 61, no. 1, 21-26, 2017.

[2] R.A. Heifetz, A. Grashow, and M. Linsky, *The Practice of adaptive leadership: Tools and tactics for changing your organization and the world.* Harvard business press, 2009.

Recommended Reading

Sample reading list from the course:

P. Mang, B. Reed, and Regenesis, *Regenerative development and design: A Framework for Evolving Sustainability*. Wiley, 2016.

N. Theise, *Notes on Complexity: A scientific theory of connection, consciousness, and being*. Spiegel & Grau, 2023.

L.C. Spears, "Character and servant leadership: Ten characteristics of effective, caring leaders", The Journal of Virtues & Leadership, vol. 1, no. 1, 25-30, 2010.

S.M. Cannon, "Climate strikes: Greta Thunberg calls for 'system change not climate change' – here's what that could look like", The Conversation, March 15, 2019. https://theconversation.com/climate-strikes-greta-thunberg-calls-for-system-change-not-climate-change-heres-what-that-could-look-like-112891

C. Rayner, and F. Bonnici, *The systems work of social change*. Oxford Press, 2021.

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