

Putting the (Social and Environmental) 'Context' in Context-Rich Problems

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Dr. Koh joined the Smith faculty in 2019 after earning a doctorate from the University of Massachusetts Amherst in 2017 and teaching at Lafayette College in Easton, PA, for two years. They are eager to collaborate with others thinking about how to teach sustainability and equity in engineering.

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Background

The learning objectives for the class are inspired by Myles Horton and bell hooks who- in their exploration of democratic classrooms- said that as educators and learners we seek to transform consciousness, to learn ways of knowing that enable us to know ourselves better and live in the world more fully [1, 2]. This paper follows on the author’s previous work [3], which argues for the *repoliticization* of engineering knowledge through curricular interventions for a more liberatory engineering education. Interdisciplinary and context-rich approaches have been shown to elicit deeper learning in general [4], and to engage marginalized students more effectively [5]. One of Horton’s theories is that learning takes place through cycles of reflection and action to transform the world, and reflection plays an important role in deep learning [6, 7]. Taken all together, this course sought to employ context-rich, interdisciplinary, and reflective approaches to engineering education.

Example Course on Sustainable Materials

The curricular design for Sustainable Materials is one answer to how to put the (social and environmental) ‘context’ into context-rich engineering problems. A curricular overview is presented in Table B1 (Appendix B), including the four units of the course and the summative assignments for each unit. Units 1 and 4 provide scaffolding and reflection (i.e. the “context richness”) for the engineering work done in Units 2 and 3. Unit 1: Towards a Collective Definition of ‘Sustainability’ in Engineering is the primary focus of this paper because it had an important influence on setting the tone of the class.

Weekly Topic	Reading Assigned	Themes from Class Discussion
What are we doing here? How Students Learn and How Engineers Design	<i>Teaching Community</i> by bell hooks. [2] Ch 4: Democratic Education	purpose of education, meaning of engineering science degree, inequality and marginalization in schools
	<i>Braiding Sweetgrass</i> by Robin Wall Kimmerer [8] Ch. 1: Sky Woman Falling Ch. 3: The Gift of Strawberries Ch. 5: Asters and Goldenrod	Indigenous and Western perspectives on science and economics, climate crisis
	<i>Design Justice</i> by Sasha Costanza-Chock [9] Introduction: #TravelingWhileTrans, Design Justice, and Escape from the Matrix of Domination	meaning of ‘engineer’, purpose of engineers in society, bias and discrimination in AI & big data
Environmental Justice	<i>How to Change Everything</i> by Naomi Klein [10] Ch. 3: Climate and Justice <i>Principles of Environmental Justice</i> from the People of Color Environmental Leadership Summit [11]	environmental justice, disaster response, compare/contrast principles of engineering design and environmental justice
	Excerpts from Walker’s <i>Environmental Justice: Concepts, Evidence, and Politics</i> [12] Tar Creek (film) [13]	holistic / systems thinking, community impacts in engineering designs
	<i>This Changes Everything</i> by Naomi Klein Ch. 2: Hot Money: How Free Market Fundamentalism Helped Overheat the Planet [14]	connection between capitalism and climate crisis, engineers’ role in the climate crisis

Table 1: Curricular design for Unit 1: Towards a Collective Definition of ‘Sustainability’ in Engineering

Table 1 details the weekly topics, associated readings (per class period), and the themes from the class discussion for Unit 1. Students worked together with the faculty member to scaffold the dialogue process based on principles of democratic education [2]. The listed class periods were spent in dialogue about the reading (with discussion questions assigned ahead of time, e.g. see Appendix C) and varied in format between small group and large group discussion, with some class time set aside for work on the class' first summative assignment, Principles of Sustainable Design.

Evidence of Success

Students completed journal entries after each class in this unit, where they reflected on the reading and the class dialogue. The following quotations show examples of student thinking in which they are developing values, connecting emotionally to the readings and each other, and wrestling with big ideas.

“I want to learn not for a test but to enrich my life with knowledge and understanding of what is happening around me.”

“It is difficult to remain optimistic and hopeful about the future of the environment when [...] the constant prioritization of the economy continues to have direct negative impacts on the environment. On the other hand, I feel like it's important to remain hopeful in order to meaningfully contribute to the positive changes that are in progress and encourage others to also contribute.”

“One thing that stuck out to me in the documentary was how the EPA said they divided up the problem area into units rather than looking at the problem as a whole. I really hope that the Smith engineering education will allow me to look at problems as a whole or at least be more aware of what my blind spots are/what things I may be less knowledgeable about so that I will be able to look at problems more holistically and not create more problems by trying to solve one problem.”

Elements of Success

There are three main elements to the course design that were especially effective in this course:

- (1) The students were members of a strong **cohort**. They were all senior students in a relatively small graduating class who had bonded both through intentional cohort-development efforts in [institution]'s first-year courses, and also less formally through the shared experience of leaving and coming back to campus through the COVID-19 pandemic. Throughout the program, students received consistent messaging about the importance and value of collaboration and teamwork.
- (2) The group explicitly addressed our purpose for **rich dialogue** and practices for communication with each other. Students worked together with the faculty member to develop the class discussion process, and were encouraged to pose questions for dialogue (instead of just answers).
- (3) The reading assignments provoked abundant discussion by using **storytelling** to reinforce values, principles, and ideas. hooks, Costanza-Chock, Kimmerer, and Klein are especially effective in their use of storytelling and resonance with students.

Lessons Learned

Faculty often hesitate to broach subjects that are outside of their areas of expertise, but they need not be an expert on every topic. Democratic education allows for faculty members to learn with and alongside students, so long as they act as effective facilitators. The reading assignments in this course allowed the students and faculty to explore new ideas and build knowledge together, without the faculty member being an expert in every area. Still, the course could be improved by including a faculty member who is more expert in environmental studies. The topic is ripe for co-teaching and the dialogue around environmental studies could have benefitted by being underscored by a stronger theoretical framework.

References

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- [10] Klein, Naomi. *How to change everything: The young human's guide to protecting the planet and each other*. Atheneum Books for Young Readers, 2021.
- [11] Principles of Environmental Justice. From People of Color Leadership Summit, 1991.
<https://www.ejnet.org/ej/principles.pdf>
- [12] Walker, Gordon. *Environmental justice: concepts, evidence and politics*. Routledge, 2012.
- [13] Tar Creek (film). Directed by Matt Myers. Produced by Tanya Beer, Ron Beer, and Cara Beer. 2009.
- [14] Klein, Naomi. *This changes everything: Capitalism vs. the climate*. Simon and Schuster, 2015.

Appendix A: Course Learning Objectives

Students will:

- Deepen their capacity to live fully in the world;
- Improve their ideas through dialogue with one another;
- Generate design principles for sustainable materials;
- Author a curriculum on an alternative material, manufacturing process, or design practice that improves sustainability compared to conventional design;
- Perform a Life Cycle Assessment on an engineering design or product;
- Grow their capacity to become lifelong learners.

Appendix B:

Unit	Major Assignment
1: Towards a Collective Definition of ‘Sustainability’ in Engineering	Principles of Sustainable Design
2: Engineering Materials: How Stuff Gets Made, and What it Costs	Alternative Material Curriculum
3: Towards Sustainable Materials	Life Cycle Assessment
4: Beyond Sustainable Materials: Hope for the Future	Portfolio of Reflection Journal Entries

Table B1: Curricular Overview for Sustainable Materials Course

Appendix C: Sample Discussion Questions

- Where do you see Indigenous and Western perspectives on science interacting? How are they connected? Where do they diverge?
- Consider the passage from the bottom of pg. 5 through pg. 6 of *Skywoman Falling*, where Kimmerer talks about her Ecology students' views on the interactions between humans and nature. Do you identify with what her students said? Why do you think she shared this story?
- On pg. 9-10 of *The Gift of Strawberries*, Kimmerer describes dreaming of a market where "gratitude was the only currency accepted". She says, "when everything became a gift, I felt self-restraint." What is she trying to illuminate here-- what is the lesson?
- In chapter 5, notice anything that speaks to our previous reading (*Democratic Education* by bell hooks), and anything that speaks to your own story.
- How do you think Dr. Kimmerer would describe "sustainability" or "sustainable materials"?

Appendix D: Institutional Context

Sustainable Materials was offered at Smith College as an upper-level technical depth elective course in the Fall 2021 semester. Smith is a private liberal arts college with one engineering degree program (B.S. Engineering) and approximately 30-45 graduates per class year in recent years. Technical depth courses offer students the opportunity to explore a topic area in depth, and can allow students to informally concentrate in a particular area or discipline (e.g. sustainability or electrical engineering).