Board 308: Improving Students' Sociotechnical Literacy in Engineering

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Abstract

The *Improving Students' Sociotechnical Literacy in Engineering* project aims to integrate social justice topics with technical knowledge in a first-year engineering course. The approach involves redesigning an existing intro to computing course with justice-based activities, supported by an Equity Learning Assistant (ELA) program. This program trains upperclass students to facilitate in-class discussions on equity and social justice. The project targets improvements in students' critical sociotechnical literacy and engineering identity. Activities include analyzing ethically complex data sets and developing equity-focused projects, while encouraging students to integrate social, economic, and political dimensions into their engineering work. This initiative spans four years (one pilot year plus three NSF-funded iterations) and involves a multidisciplinary research team of engineers and education researchers.

Description

As means of enhance students' understanding of the societal impact of engineering solutions, and starting this process in the very first-year of university engineering, the *Improving Students' Sociotechnical Literacy in Engineering* project's approach seeks to develop critical sociotechnical literacy, allowing students to consider social, economic, and political dimensions in their engineering work. It's designed to foster a more inclusive and socially conscious engineering identity, highlighting the importance of ethical considerations in engineering practices. This integration is crucial for preparing future engineers to address complex real-world problems that span beyond technical solutions.

The existing computing course (*Introduction to Computing for Engineering*, typically taken by most engineering students in the spring semester of their first-year) historically was focused on teaching the technical concepts of coding and an introduction to data science (data manipulation, visualization, and interpretation). The experimental redesign of the course involves incorporating justice-based activities that encourage students to analyze ethically complex data sets and develop equity-focused projects. This approach is designed to simultaneously teach computing technical skills while integrating social, economic, and political dimensions into engineering work. The course redesign includes three main components:

1. Small group and whole-class discussions led by the instructor and supported by *Equity Learning Assistants (ELAs)*, who are trained in equity pedagogy. These activities, typically once a week during a lab session, aim to make students aware of the societal implications of their engineering decisions and encourage them to critically evaluate data and technology within broader sociopolitical contexts. Each lab is followed by a reading and reflection assignment to develop deeper understanding of the in-class work and provide additional resources for students.

2. Integrated project weeks featuring new course content developed as part of this project, with specific focus on engineering activities that include both computational challenges as well as social and political context and implications.

3. Inclusion of sociotechnical analysis and reflection in students' final projects, where self-directed individual (or small group) final projects focus on student-selected data sets and computational techniques for analysis. Final report requirements now feature equity and impact reflections.

Below in Table 1 are the lab activity topics and brief description for the first twelve weeks of the fourteen-week semester.

Table 1. Sociotechnical Lab Activities by Week Number

Week #	Topic	Description
1	Tenets of Sociotechnical Thinking	Setting class rules/norms; Impact maps
2	Gender in Car Crash Data	Data visualization/interpretation, government oversight
3	Myth of the Impartial Machine	Non-representative data vs historical social bias
4	Infection Control	Experimenting with infectious disease modeling and discussing impact
5	Disability in Design	Usability and web-design, ADA, web-standards, testing
6	Transit Equity	Equitable fare structures on public transportation
7	Offshore Wind Analysis	Turbine design vs job creation and environmental impact
8	Energy Injustice	Bias and blind spots via racial disparities in rooftop solar installation
9	"Are We Automating Racism?"	Machine learning and racist outcomes
10	Geopolitical Analysis	Perspective of stakeholders to understand impact/complexities
11	Tech in Hiring	Human bias vs machine bias in automated processes in job hiring
12	Racial Bias in Medical Equipment	Pulse oximeter case study

The project weeks featured larger projects that were designed to teach computing technical skills (coding and data science) while still integrating discussions and considerations of the social, economic, and political dimensions of the engineering decisions and potential impact into the work. Table 2 highlights the five projects that happen during the semester.

Table 2. Larger Sociotechnical Projects by Week Number

Week #	Project Name	Description
3	Infection Disease (SIR Modeling) Simulation	Exploration of SIR Modeling and experimenting with inputs (and resulting outputs), specifically within the context of the Coronavirus. Introduction to simulation and data visualization and interpretation.
5	Transit Equity on the MBTA	Introduction and modeling of economic principles (elasticity of demand); computation of system-wide impacts of theoretical fare changes and discussions around equity and potential impact on different populations within the Boston area.
7	Solar Panel Installation	Based on research into racial and ethnic disparities in solar panel installations nationwide, this project introduced students to datasets (census data, solar installation data). Students analyzed and visualized solar-installation rates vs medium income and compared across different racial/ethnic segmentations.
9	Water Demands in the Indus Basin	Looking at historical data, current data, and predictive data around water use (and associated environmental/societal impacts) in the Indus Basin and cooperative geopolitical agreements amongst countries (e.g. specifically India and Pakistan). Modeling of water sources and use (energy, food, industry) and balancing associated shortages (with investment in improvements, eg. more efficient energy production or more efficient farming techniques) as the population grows.
11	Medical Data Analysis	Machine Learning (supervised and unsupervised classification) on medical data (e.g. hemoglobin vs glucose and identifying chronic kidney disease); paired with sociotechnical discussions of medical bias, human roles in machine learning, etc.

These course modifications, leading to social justice topics being tightly integrated alongside technical knowledge throughout the entire semester of this first-year computation course, will provide students with opportunities early in their education to practice integrating social, economic, and political dimensions into their engineering work. Long term (and especially if reinforced through similar modifications in subsequent engineering courses) this work should develop undergraduates' sociotechnical literacy, their sense of belonging in engineering, and a refined perspective of not only the role of engineered solutions in the world but their own responsibility in the creation of those solutions.