# Making the Invisible Visible: Integrating Engineering-for-Social-Justice Criteria in Humanities and Social Science Courses

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## Abstract

Engineering practice always involves social and technical dimensions. However, the bulk of an engineering education gives students little practice in thinking sociotechnically. The organization and content of the curriculum is much at fault here. While engineering science courses focus largely on the technical, engineering design courses sometimes integrate the social and the technical but in ways where the social is reduced to economic and client-based constraints at the expense of broader socio-cultural dimensions. Meanwhile, courses for undergraduate engineers in the Humanities and Social Sciences (HSS) focus largely on the social but marginalize linkages to the technical. This paper addresses the sociotechnical gap in the HSS by identifying six classroom-tested Engineering for Social Justice criteria. We examine how those criteria function to foster enriched learning on the sociotechnical dimensions of engineering practice in two HSS courses. To conclude, we discuss both the benefits and limitations of using those criteria.


## Introduction

Although law, medicine, and other professions have long had curricular components focused on social justice (SJ) responsibilities for future professionals, engineering has far fewer explicit connections to SJ.[1] Research suggests the exclusion of SJ is not merely related to engineering being a "technical" profession. Instead, engineering ideologies[2] and mindsets in engineering[3] perpetuate the invisibility of SJ inside engineering education. Of the three primary components of the engineering curriculum—courses in the engineering sciences, engineering design, and Humanities and Social Sciences (HSS)—the engineering sciences have been critiqued for their exclusive, narrow technical focus,[4] and engineering design for not making SJ more visible.[5]

While the engineering sciences often exclude inherent social and SJ dimensions and focus largely or exclusively on *technical* dimensions, HSS courses for engineering students often do the opposite: they focus on *social* (and sometimes SJ) dimensions but exclude technical ones. With the exception of Science and Technology Studies (STS) and occasionally Professional Communication and Engineering Ethics, most HSS disciplines rarely try to bridge the social and the technical. Combined, this dichotomy of the engineering curriculum into the technical (engineering sciences) and the social (HSS), with perhaps some occasional (yet often superficial) *sociotechnical* integration in engineering design, constitutes a disservice to future engineers. Engineers-to-be need to practice thinking not just technically or socially, but *sociotechnically.* By practicing sociotechnical thinking, engineering students can improve their ability to define and solve problems in ways that accentuate interplays between the social and the technical—that is, to see how social dimensions shape (and are shaped by) technical artifacts and systems (for more on sociotechnical thinking, see [2 6 7 8]). Only then will engineers be able to bring SJ purposefully and explicitly into their practices—problem definition and solving, design, analysis, modeling, operating, and others—for the human groups they are hoping to serve and impact.

**Engineering for social justice criteria**

To challenge the technical-social dichotomy, we have researched and developed six Engineering-for-Social-Justice (E4SJ) criteria.[4 5] Here we use those criteria to shape the content and evaluate the effectiveness of two HSS courses, which include considerable sociotechnical dimensions. We explore the degree to which these two courses enact several of the E4SJ criteria.

Here we define **engineering for social justice** as engineering practices that strive to enhance human capabilities (goal) through an equitable distribution of opportunities and resources while reducing imposed risks and harms (means) among agentic citizens of a specific community (a definition synthesized from [9 10 11 12]). The E4SJ criteria emanate from that definition. Although a more thorough explanation of the E4SJ criteria below appears elsewhere (e.g., [4 5]), the italicized criteria are posed briefly below as questions, which can enable educators to use them as heuristics in evaluating HSS courses and their contribution to integration social justice in engineering curricula.

1. How well does a course help engineers *listen contextually* to diverse users and actors so the ways in which the social context shapes (and is shaped by) the technical becomes visible? How effectively does the course help engineers and other stakeholders *listening* to discover more about criteria 2-6 below?
2. How thoroughly does the course help engineers and other stakeholders *identify structural conditions* so legal, historical, political, economic, and other social structures that serve as real or potential project-related barriers and/or opportunities to users, key actors, or engineers become visible and are openly acknowledged in the problem definition and solution process?
3. How does the course help engineers and other stakeholders *acknowledge political agency and mobilize power*, so they can identify forms of political agency (of users, key actors, and engineers' own) to mobilize available sources of power to enact a more socially just engineering product or service?
4. How does the course help engineers focus their practices on *increasing resources and opportunities,* so the engineering product or service can increase for users access to resources (e.g., water, energy, money) and opportunities (e.g., steady income sources, access to education, promotion of technology, health and/or infrastructure)?
5. How does the course help engineers focus on *decreasing risks and harms,* so the engineering product or service can reduce the public's exposure to risks (e.g., safety, environmental) and harms (e.g., restricted access to education, technology, and/or infrastructure)?
6. Overall, how does the course help engineers to ensure that project outcomes *enhance human capabilities,* so the engineering product or service can augment capabilities such as bodily health; bodily integrity; senses, imagination, and thought; emotions; practical reason; affiliation (protecting entities that ensure preconditions for self-respect and non-humiliation regardless of sex, ethnicity, sexual orientation, etc.); play (recreation, laughter); and control over one's political and material environment (capabilities from[11])?

Below we describe two HSS courses that attempt to render visible sociotechnical dimensions by integrating select, project-relevant E4SJ criteria.

**Intercultural communication**

Intercultural Communication was offered beginning Fall 2014 due to student interest. Students expressed interest in augmented capabilities in navigating the international and intercultural contexts they were likely to encounter at work, in travel, and as global citizens. After graduation, many of our graduates enter multinational corporate contexts. For brevity, we showcase below how the E4SJ criteria relate to one assignment.

In examining intercultural communication theory and practice, students in Intercultural Communication gain a window into how cases of intercultural (mis)communication arise, evolve, and are addressed (worsened, resolved, etc.). Students investigate communication cases and issues across a range of complex cultural divides, such as national, gender, social class, and ethnic/racial cultures. Broad, multidisciplinary definitions of culture include culture as shared (and sometimes contested) meaning (anthropological), culture as contested meaning (cultural studies), and culture as resource (global studies).[13] Some case studies, like the one described below, are situated in engineering and applied science contexts.

*Vehicles for increasing the visibility of social justice*

To help students identify the SJ dimensions in intercultural communication case studies, among other activities students evaluated how well project engineers engaged the above E4SJ criteria. For instance, one case involved U.S.-based civil engineers with clear sustainability objectives engaging community members in rural India. Although the India-based nongovernment organization they partnered with informed them that locals in Sika Dhari desired a water and sanitation system, when the team of civil engineers arrived, having learned some Hindi and researched diverse possible sanitation systems, the locals mostly spoke a tribal language and they indicated they wanted an electricity-generating windmill. Communication was further hampered by the presence of an Indian engineer who had moved to Sika Dhari and served as translator—and who also indicated his distrust of foreigners and their development ideas. The civil engineers also had reason to doubt his trustworthiness.[14]

*Assessment and broader impact*

In the case study on Sika Dhari's windmill, students were asked in class to identify which one of the six E4SJ criteria they thought the civil engineers enacted most and least effectively throughout the project and to justify their decision with a clear rationale. Clustered into four groups, students in two groups indicated that the engineers most effectively enacted *listening contextually,* largely due to the engineers' elaborate participatory community mapping process, which included among other aspects local community members drawing maps to show the community's relation to their environment and to each other, as well as drawing who is and is not part of the community. In contrast, the other two groups chose *identifying structural conditions* that maintain (in)equalities, due mostly to recognizing that the windmill was a form of protest against hydropower dams, the construction of which had caused flooding and displacement in nearby rural villages. After some debate, student groups were asked if they had been persuaded to change their positions, which no group did; several students, however, noted that they better understood why both criteria were enacted as well as could be expected under difficult circumstances.

When asked to vote on the least effectively engaged criterion, the vote was again split 2-2, but not along the same group lines. For two groups, the civil engineers could have improved most in terms of *acknowledging political agency and mobilizing power*, particularly after discovering the language barrier and translator issues. The other two groups said most improvement was needed in terms of *reducing risks and harms,* as the thoroughness of windmill safety testing was a serious question, particularly after the civil engineers left Sika Dhari. As before, the two groups debated and although they better understood their respective positions, they stayed with their original votes. Students indicated that the windmill in Sika Dhari may have *enhanced human capabilities*, but that could only be decided over the long run and primarily by locals.

In general, we interpreted student engagement with and case-study application of the E4SJ criteria as an indication students not only understood the criteria, but could also analyze and evaluate them well enough to argue for or against their inclusion/exclusion in the process of deciding which criteria were the most or least effectively engaged. Furthermore, student use and evaluation of the criteria to an actual engineering case study constitutes a form of sociotechnical application, wherein students analyzed and reflected on the complex interplays of the social and the technical. Overall, the E4SJ criteria evaluation process via case studies provided students with concrete, specific opportunities to evaluate the utility of the criteria and to understand how they apply and add value to *sociotechnical* engineering practice. Whereas in the example of Intercultural Communication we showed how we introduced students to the E4SJ criteria through the lens of one case study, in the course below, we provide a closer look at how the E4SJ criteria emerged and were refined from teaching a course on Engineering and Social Justice.

**Engineering and social justice**

The course Engineering and Social Justice originated through our experiences with prominent engineers who assumed that engineering and SJ were completely separate.[15] Some even resisted attempts to bring the two areas of practice into dialogue. To understand such resistance, we submitted and secured a National Science Foundation grant to explore the historical origins of this separation, and where and how engineering-SJ connections actually took place (Progressive Era, New Deal, Counter-culture movement of 1970s, Counter-neoliberal movement at turn of 21st century), and what conditions led to their separation (and seeming incommensurability) throughout the late 20th century. The grant gave us the legitimacy to develop, pilot and make permanent our course Engineering and Social Justice, in an institutional setting that tends to be conservative and aligned with powerful corporate interests. The official course description states that it "offers students the opportunity to explore the relationships between engineering and social justice through personal reflection and historical and contemporary case studies."

*Vehicles for increasing the visibility of social justice*

We begin the course by making a crucial distinction: being charitable and helping others is not the same as enacting SJ. The former focuses on individual actions that try to minimize immediate human suffering (e.g., handing out change to a homeless person; volunteering for Habitat for Humanity). By contrast, the latter challenges people to reflect and act on the underlying systemic forces that cause the suffering and try to change them (e.g., what are the root causes of homelessness and what can engineers do to overcome these?). To identify such forces, engineers need to *listen contextually,* so they glean perspectives from multiple perspectives within a given social context (surrounding homelessness, etc.). In the US, the above distinction helps students *identify structural conditions* and distinguish between initiatives that generally do not address underlying systemic forces that maintain the status quo (often promoted by wealthy, powerful interests that endorse charity and philanthropy) and SJ initiatives that advocate for systemic reform.

Students then do a privilege walk[16, 17] to debunk the myth that students, by virtue of being in the same class or enrolled in the same school, start and live life from the same position of advantage. As students take steps forward (or backwards) according to the privileges they have (or don't have) based on the social categories to which they belong (gender, race, ethnicity, socio-economic class, first generation to attend college, religious affiliation, physical ability, etc), a social hierarchy of privileges is revealed in front of their eyes. They are in it so it becomes difficult to deny it. Through this exercise, we begin to help students challenge the ideology of meritocracy[2, 18] and hence to identity further structural conditions and begin to acknowledge that, by virtue of their own privileges, they have augmented *political agency* that can be marshaled to benefit those most impacted by engineering outcomes.

During the historical analysis of engineering mindsets and ideologies, students learn to further *listen contextually* so they can *identify structural conditions* that shape, for example, historical definitions of engineering (e.g., distinguishing it from home economics to keep women out[19] or a more recent definition that emphasizes abstract analysis over experiential knowledge, thus privileging middle-class over lower-class students[20]), and the context of engineering education and focus of engineering problem solving (e.g., how the military-industrial complex shaped engineering education institutions and what problems are worth solving)[21]; we also explore the myth that engineering is objective and only based on empirical data.[3] This historical analysis helps students begin to see how the engineering profession has historically *increased opportunities and resources* and *decreased risks and harms* for some segments of society while ignoring or marginalizing others. Hence students begin to wonder how they can begin to correct this imbalance, and most become eager to learn strategies to counteract the blinding effects of ideologies[2] and mindsets.[3]

Students also learn from real case studies of exemplary engineers who have practiced engineering for SJ, i.e., *increasing resources and opportunities* and *decreasing risks and harms* for the purposes of *enhancing human capabilities,* such as Transmilenio engineers in Bogota, Colombia[22], engineers fighting against a community relocation in a mining site in Peru[23], and LGBT[24] and low-income/first generation (LIFG) activist engineering students.[25] Students conclude the class by researching and presenting case studies of their own and then reflecting on the challenges and benefits of working as engineers for the *enhancement of human capabilities* from now on.

*Assessment and broader impact*

In this course, we use a pre/post course questionnaire to assess student understanding of 1) SJ as a concept, 2) the past and present intersections of engineering and SJ, and 3) students' current relationship with SJ as engineering students. In the pre-course questionnaire, student responses varied but included recurring themes, as many students respond 1) as either accepting ignorance ("I have almost no understanding of social justice") or focusing on retributive justice ("when the legal system decides consequences of crimes"); and they respond 2) mainly in a negative way ("engineers causing harm to people via flawed designs") and very few in a positive way, but magnifying microethics ("engineers working as professionally and ethically as possible") while ignoring macroethical dimensions[26] of SJ; and respond 3) as relying on external agents to establish the relationship with SJ for them ("I rely on the police and on judges to make calls in the right direction").

In the post-course questionnaire, students display increased sociotechnical awareness. Specifically, students repeatedly frame SJ as a concept and set of practices aimed at "promoting equality of opportunity" and one that those with privileges, including themselves as engineering students, should embrace "to try to even the field for those with less privilege." Furthermore, based on case study discussions (e.g., on [25 24]), they have come to realize that engineering education has built in social injustices as "some students are more privileged than others, [like] LIFGs [low-income, first-generation] and LGBT [lesbian, gay, bisexual, and transgender] students who face structural barriers" and, perhaps more importantly, that in engineering education and the workplace "ideologies and mindsets perpetuate social injustices." Such forms of sociotechnical awareness position engineering students to be more able to challenge prevailing engineering ideologies and mindsets, which seek to render SJ invisible or irrelevant.[2 3] Such awareness is designed primarily to augment the capacity for integrating sociotechnical dimensions throughout the engineering problem defining and solving process.

## Benefits and limitations

Within the context of engineering education, what are the benefits and limitations of making SJ visible via the E4SJ criteria in HSS courses? From the above instructional experiences, several benefits and limitations have emerged.

*Benefits*

- By rendering visible SJ in light of engineering case studies, engineering students can identify the *sociotechnical* connections between SJ and engineering in specific instances, and come to see the value of using a SJ lens as one form of formative and summative project assessment. Such learning experiences can help rupture the technical-social dualism common to engineering curricula.
- As instructors, we have found a tremendous sense of reward in reflective, thoughtful student responses to activities that help all of us become more aware of our privileges, their unequal distribution across society, and actions that result from that awareness. For instance, after

doing the privilege walk, one student wrote that "One cannot control how one's privileges come about but one can control *what one does* with privilege."

- Although there was a time when writing an NSF proposal that focuses on rendering SJ visible in engineering education was seen as highly risky, it appears that time has now passed. A search of NSF databases will show that an increasing number of grants explore questions related to access, recruitment, and retention of underserved groups in engineering education (LIFG, LGBT, and others), and a few of them are focused on the engineering curriculum itself and SJ issues.
- SJ can be judiciously integrated into and clearly complement the course goals of multiple HSS courses, such as in service learning, communication, STS, anthropology, sociology, etc.

*Limitations*

- Any instructor who has attempted to make SJ visible in HSS courses will acknowledge that it is difficult to give SJ its full due. SJ research straddles multiple disciplines (philosophy, social work, sociology, economics, etc.) that cannot fit in a single course focused on Engineering and Social Justice, Intercultural Communication, or likely any other. Instructors need to remain true to course learning objectives and not let SJ hijack a course, even if the SJ content is rich and varied.
- Attempts to integrate all six E4SJ criteria should be treated with caution, especially in a first course iteration. Instead, instructors should focus on those criteria most relevant to particular case studies, especially those that are nuanced and complex, like actual engineering practice.
- Some colleagues may not understand why rendering SJ visible adds value to HSS courses for engineers; however, that limitation can be turned into an opportunity to clarify the learning benefits.
- When undergraduate engineering students arrive in an upper-division HSS course, they already have been socialized to think technical-social dualism is a normative framework for discussing "real" engineering.[27] [28] Hence, some patience is warranted to give students time to challenge (invisible) engineering educational norms.

## Future work

As this research evolves, the focus will center on two main issues. First, more assessment data will help us understand student perceptions on the sociotechnical emphasis and on making SJ visible. Also, more in-depth knowledge of student performances on assignments that seek to promote SJ visibility can help bolster the ability of those (revised) assignments to challenge common assumptions about engineering and engineering education. Finally, we would like to evaluate how our courses impact students' professional careers in the short and long terms, from their choices about employment to their encounters with social injustices in the workplace.

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