121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #10351

What is Design for Social Justice?

Dr. Jon A. Leydens, Colorado School of Mines

Jon A. Leydens is an associate professor in the Division of Liberal Arts and International Studies at the Colorado School of Mines, USA, where he has been since 1997. Research and teaching interests include communication, social justice, and engineering education. Dr. Leydens is a co-author of Engineering and Sustainable Community Development (2010). He recently served as guest editor for an engineering communication special issue in Engineering Studies and won the James F. Lufkin Award for the best conference paper—on the intersections between professional communication research and social justice—at the 2012 International Professional Communication Conference.

Dr. Juan C. Lucena, Colorado School of Mines

Professor Lucena is Director of Humanitarian Engineering at Colorado School of Mines and teaches Engineering & Sustainable Community Development and Engineering & Social Justice. Juan obtained a Ph.D. in STS (Virginia Tech) and two engineering degrees (Rensselaer). His books include Engineering and Sustainable Community Development (Morgan &Claypool, 2010) and Engineering Education for Social Justice (Springer, 2013). He has researched under grants like Enhancing Engineering Education through Humanitarian Ethics, and Invisible Innovators: How low-income and first-generation students contribute to US engineering.

Dr. Dean Nieusma, Rensselaer Polytechnic Institute

Dean Nieusma is Associate Professor of Science and Technology Studies and Director of the Programs in Design and Innovation at Rensselaer Polytechnic Institute. He is also co-Editor of the International Journal of Engineering, Social Justice, and Peace.

What is Design for Social Justice?

…technology only expands human capabilities when appropriately embedded in wider social and physical structures.
--Oosterlaken (p. 8)[1]

Introducing a technology may create process efficiencies and in turn eliminate jobs. It can lower the cost of goods while promoting waste and consumerism. In playing an essential role in the process of economic and social development, introducing a new technology may produce undesirable and unintended social transformations, involving moral issues such as child labor, women's economic participation outside the home, and democracy.
--Nichols and Dong (p. 190)[2]

Abstract

Design for technology, which prevails in engineering design courses, addresses constraints such as budget, time and functionality established by a client. Meanwhile, human-centered design (HCD) emphasizes users' needs, desires, and cultural location, mainly through ergonomics and esthetics.[3] Although an established concept and practice in design studies and some forms of industrial design, HCD has evolved to consider low-income and underserved communities as users, challenging engineering design education to incorporate listening to users; accommodation of human capacities, needs, and desires; and attention to people's culturally situated resources, resource limitations, and opportunities.[4] Despite its potential to push engineering education in productive directions, HCD also has its limitations, particularly its inability to grapple with the structural conditions that give rise to many of the needs HCD seeks to address. More generally, HCD can direct attention away from the critical and sometimes-subtle dimensions of social justice.[5] Design cases that involve, for example, "design for the other 90%"[6] or designing for people with disabilities redirect attention to questions of design for social justice. This paper identifies and briefly describes four forms of design: design for technology, HCD for users, HDC for communities, and design for social justice. The paper explores how social justice has been enacted—or neglected—in specific design contexts within engineering education, and how it can be further integrated in each of these forms of design education.

This paper is part of a broader project to integrate social justice across three components of engineering curricula—engineering design, engineering sciences, and humanities and social sciences courses. To explore design-for-social-justice education in concrete terms, our investigation provides a specific, field-tested definition of social justice and draws from enactments of engineering for social justice in specific design courses: a human-centered problem definition course in the Humanitarian Engineering Program at the Colorado School of Mines, an interdisciplinary design studio in the Design, Innovation, and Society program at Rensselaer Polytechnic Institute, and a learning-through-service experience in a first-year Biological Engineering design course at Louisiana State University. Our investigation culled data from semi-structured interviews with course instructors and students, reviews of course documents, contextualization within the literature on design, and our own lived experiences working with design students. Through this investigation, the paper seeks to provide: 1) a set of emerging principles of design for social justice and 2) examples of how those criteria are enacted in instructional design contexts. Such research outcomes can improve our understanding of how design for social justice can inform design in community engagement contexts.

I. Introduction

In the context of engineering design, the old saying that a problem well defined is half solved can be instructive. What is included and emphasized in the problem definition phase? What is excluded and de-emphasized? And how does one's approach to problem definition shape one's solution? Our broad focus here is to explore the question, "What is design for social justice?" To investigate that question, we will first explore some common design strategies and how each generally defines and places boundaries around engineering design problems. Like any exploratory paper, this one will raise more questions than it addresses. Beyond exploring design for social justice, our paper is guided by two overarching questions: How do common engineering design strategies intersect, if at all, with dimensions of social justice? What engineering design instructional examples exist that attempt to engage these dimensions of social justice?

Design for social justice comes into relief when compared with other design strategies. Here design for social justice interfaces with three other design strategies: design for technology, human-centered design (HCD) for users, and HCD for communities.

Design for technology, which prevails in many engineering design courses, focuses almost exclusively on matters of technical feasibility and economic viability in a commercial context. It addresses constraints such as budget, time, and functionality established by a client. As the name implies, the design is focused on producing a particular technological product or service tailored to the client's needs and expectations as well as to realistic physical (e.g., manufacturability), economic, and other constraints. By contrast, *human-centered design for users* focuses on the desirability of the designed object, emphasizing users' needs, aspirations, and cultural locations, mainly through ergonomics and esthetics.[3] Although now a well-established concept and practice in design studies and some forms of industrial design, HCD has more recently evolved to incorporate community perspectives that exist beyond individual user's desires and, of special significance to our analysis, design practices that exist alongside typical commercial contexts. *HCD for communities* considers low-income and underserved communities as users, challenging engineering design education to incorporate listening to users; accommodation of human capacities, needs, and desires; and attention to people's culturally situated resources, resource limitations, and opportunities.[4] Although these same challenges exist in HCD for users, the designer-user relationship shifts in HCD for communities: whereas in commercial contexts, the user is the client and has considerable sway over the designer, in community contexts, the user is often an aid recipient, which can enable a designer's misguided assumptions to hold more sway. To counteract that tendency and enact HCD for communities, designers are guided "through a process that gives voice to communities and allows their desires to guide the creation and implementation of solutions" (p. 5).[4]

To understand *design for social justice*, we need to first explore the polysemic term social justice. Although multiple definitions exist, our field-tested definition has evolved over several years from multiple iterations of teaching a course on Engineering and Social Justice. In relationship to engineering, we define social justice as engineering practices that strive toward an equitable distribution of **opportunities and resources** in order to **enhance human capabilities** while **reducing imposed risks and harms** among the citizens of a society.[7,8,9,10] In sections II and IV, we elaborate on how this definition informs engineering design.

For the remainder of this paper, each section focuses on a particular question:

- How does design for social justice compare with other design strategies? (Section II)
- What actual engineering design cases can illustrate the different design strategies? (III)
- What specific criteria characterize design for social justice, and how do those criteria interface with the four design strategies? (IV)
- How do examples of engineering education design courses interface with the criteria that characterize design for social justice? (V)
- From these interfaces, what implications arise for learning-through-service work in community engagement contexts? What lessons learned emerge about design education? (VI)

To address these questions, we have drawn from several main sources: semi-structured interviews with course instructors and students, reviews of course documents, contextualization within the literature on design, and our own reflections on lived experiences working with design students. In diverse institutional and course settings, each of the authors has over 10 years of experience working with engineering design students.

II. Engineering design strategies

In each of the design types above, assuming community engagement contexts, what criteria are in—and not in—the (implicit or explicit) decision matrices students typically are taught to use when weighing different design alternatives? That is, how does each regard "optimization"—what is being optimized, why, and for whose benefit? What does each approach to design emphasize, de-emphasize, and altogether omit?

A. Design for technology

In design for technology, the dominant relationship is between client and engineering students, where the former provides specifications of cost, function, time-to-delivery, and (sometimes) manufacturability to the latter, who passively **"listen to the specs."** After years of having been educated to accept the authority of pre-defined problems coming to them in engineering textbooks,[11] students are trained not to question the legitimacy of specifications (specs), the authority of the client, or the sensibility of the client's intentions. After receiving the specs, students then embark in a one or two-semester design experience marked by a design concept review, client meetings, prototype testing (with data gathering and analysis), mid-point reviews, manufacturing and budget analyses, and a final design review. Some designs also undergo an environmental impact assessment and a social context analyses with varying degrees of efficacy.

Today, with the emergence of Engineering-to-Help initiatives,[12] design challenges increasingly come from non-commercial clients, for instance from a client with disabilities desiring a prosthetic device, or an imagined rural community client in need of a filter for removing nitrates from water. Despite that such design contexts present unique design challenges, students operating under design-for-technology assumptions still engage these challenges in the same way, where provided or assumed client specs serve as the guiding constraints for the development of science-based technology and a linear timeline of deliverables dictates the pace of the design process. Continuing to view a person with disabilities or an imagined community as a client and **listening to the spec** obscures students from seeing salient social justice considerations.[13]

This form of client-driven, technology-based capstone design course sits comfortably as the culminating experience after years of solving pre-defined problems in engineering courses, where students are taught via multiple mechanisms that what matters in becoming an engineer is mastery of math-based engineering science courses.[14] That perception of what matters can be exacerbated if students' first career position involves working for a technology-based industry, where compliance with corporate authority and the single bottom line is what ensures job security. Generally, nowhere in this process are students challenged or invited to consider the social-justice dimensions inherent in their design work, such as how designing a children's clinic can benefit from identifying the root causes of why such a clinic needs to exist; how designing an aesthetically appealing, highly functional website can account for users who may have inconsistent and/or slow download capacities; or how designing a prosthetic device for wealthy clients might leave poor veterans priced out of the market. If the focus remains exclusively on applying engineering science concepts in designing for technology, serving a client, and preparing for corporate employment, the social justice dimensions of a design are likely to remain invisible.

B. HCD for users

In HCD for users, attention shifts from a given technology's design specs as provided by the client to users' needs and desires as experienced by the users. User experiences must be explored through research and design specs distilled from wide-ranging, sometimes conflicting data points. Hence, the dominant relationship is between students as designers and users as people with specific needs situated in specific contexts. As Lucena has written elsewhere, "When designing, building, and operating technical systems, engineers often imagine three kinds of users: *passive users,* who accept or reject technological advances through market forces of supply and demand; *reflexive users*, who will use the technologies in the same ways that engineers would;[15] and *imagined or projected users* 'with specific tastes, competencies, motives, aspirations and political prejudices'[16]" (p. 31).[13] In any of these situations, students typically view users as consumers, **listen to their desires,** and focus their design on creating a positive consumer experience as the main goal. Hence, in addition to considering the constraints of design for technology identified above, design students now also consider ergonomics and esthetics with the purpose of appealing to consumer desire. Although HCD for users also works to expand the definition of "user" beyond the end user, rarely does this approach encourage students to raise questions about the social justice dimensions of their design solutions or of the broader issues of viewing users primarily as consumers and of consumerism itself as it is reinforced by design insights.

A more progressive form of HCD for users is emerging in engineering education wherein users are viewed as having needs other than those satisfied via the act of consumption itself. This form of HCD for users encourages designers to empathize with users.[17] Research in this domain suggests that an empathic design process involves multiple phases. The phases involve stepping into and out of another's lived experiences; that is, the phases begin with becoming in tune with what users are experiencing or have experienced by **listening to the other**, moving into a non-judgmental space in which one sees through others' eyes, and then returning to see how that empathic experience was instructive. Crucial to a fully empathic understanding is the recognition that empathy involves both affective and cognitive dimensions. Affective dimensions include feelings and emotional identification and responses, whereas cognitive dimensions of empathy include perspective taking, understanding, and imagining oneself in others' lived experiences.[17] While it is entirely possible to apply insights gained from empathetic design wholly within the domain of consumerist design, this form of design can also be a significant step towards design for social justice, as it challenges students to put themselves in others' shoes, perhaps inspiring questions about their ability to build human capacities, their lack of resources and opportunities, or their exposure to imposed risks and harms.

C. HCD for communities

In HDC for communities, attention shifts from users as financially enabled consumers (whose needs can be addressed best by providing the right products or services in the market) to users whose primary resource base is likely to be their local community. Hence, the dominant relationships at play here become more complex for engineering design students, including relationships with "the community" (made up of a variety of community members with diverse experiences) and ideally relationships with other disciplinary experts beyond engineering. In addition to ergonomics, esthetics, and empathy, students are explicitly challenged to consider the socio-economic and cultural contexts where community members live, work, and will ultimately use the design. Since listening to a community is more challenging and complex that listening to the desires of users as consumers or listening to an individual "other," teams in this form of design face the challenge of **listening to the local context (contextual listening)**. Contextual listening includes integrating the history and culture of the community, being open to cultural difference and ambiguity, building relationships with community members, recognizing capacities while minimizing deficiencies, foregrounding self-determination, and achieving shared accountability.[18] Grounded in contextual listening, the main goal of HDC for communities is to accommodate human capacities, needs, and desires *within the contexts in which community members live and work*, including attending to culturally situated human resources, limitations, and opportunities.

HCD for communities brings students closer still to the social justice dimensions of their design work as it necessarily grapples with the social relationships that define an individual's standing and opportunity structure within a given community context. By definition, HCD for communities avoids the tendency in design to tackle human needs as they are experienced by atomized individuals. Instead, relationships among individuals help to guide the design process. Nevertheless, while HCD for communities necessarily attends to the social relationships that undergird the lived experiences of community members, social justice is merely another dimension of the equation considered by designers and not the principle motivator or goal.

D. Design for social justice

In design for social justice, the design process is explicitly motivated by the goal of equitable distribution of opportunities and resources in order to enhance human capabilities while reducing externally imposed risks and harms. Although multiple stakeholders can play important roles, the dominant relationship is between community members and designers from engineering and other disciplines, informed by and seeking to enact social justice. In addition to listening to the local context, designers are challenged to **listen to the structural conditions** that gave rise to inequalities, including those that exist beyond the local context. That form of listening enables multidisciplinary design teams to broadly define the problem and propose solutions that attempt to increase human rights, opportunities, and resources, while reducing imposed risks and harms, all in order to enhance human capabilities.

There are a variety of ways for designers to begin listening to structural conditions without becoming, say, bona fide sociologists. One way is to first become aware that individuals' positions come from belonging to social groups that are conferred certain privileges or disadvantages. For example, the three authors of this paper are middle-class, heterosexual males with doctoral degrees and tenured academic positions in the global North. Hence, we inherit certain privileges of class, gender, and profession, among others. Second, one must realize how this privilege is connected to powerful social institutions. For example, the authors of this paper are employed not just by educational institutions but by research universities with close connections to powerful corporations and federal agencies that shape, to a large extent, which problems researchers seek to address (and which ones they do not), where graduates will find employment, and what kind of jobs they will be hired to perform, etc.

These first two phases of awareness have been compared to recognizing the effect of an airport's moving walkway.[19] (While Tatum's analogy applied to racial privilege, here we adapt it for a wider array of social privileges.) If the walkway moves in a direction that metaphorically diminishes the privileges or maintains lesser privileges of marginalized groups, doing nothing—simply remaining on the walkway—passively adds to the diminishing of human privilege, or at least sustains privilege inequality. To work against existing privilege trends, one must not only walk opposite the walkway direction, but also do so at a speed greater than the walkway (pp. 15-16).[19] One might also notice that the walkway design is fundamentally flawed, as do researchers on privilege inequality.[20,21,22]

Third, one can identify social groups that have been marginalized, disenfranchised, or ignored by powerful social institutions such as corporations, governmental agencies, and universities, and then uncover the problems that such groups deem important. For example, two of the authors work on a campus that is only 10 miles away from the poorest neighborhood in Colorado, Sun Valley, a place that generally does not benefit from the financial and social capital that circulates through nor the problems defined and researched within our university. Fourth, one can reach out to disenfranchised groups in poor places like Sun Valley, working with them to co-define problems and propose solutions using design for social justice (e.g., see [23]).

III. Case study contrasts

What documented engineering design cases can illustrate the different design strategies we have identified? Since the discussion above is rather abstract, a concrete example is warranted to contrast these strategies. Although the contrast below does not specifically engage as many components of HCD for users or communities, it does enable an illustrative comparison between design for technology and design for social justice.

A. Design for technology

Most engineering educators have seen plenty of examples of our student design teams designing for technology with industrial or corporate clients. Less obvious are examples of design for technology with non-commercial clients, which at the surface might appear as design for social justice, but actually are just centered on technology. One such design is for hybrid energy generation systems for communities in Bhutan, designed and described by Young and colleagues.[24] One of the proposed designs includes a hybrid system that combines wind, solar, hydro, and fuel-cell power for the village of Sengor, Bhutan. Their research contains no clear evidence that the project designers engaged local community members or listened to their expressed needs, desires, or aspirations. Instead, centering their process on the technology, the designers "listened to the specs" by making many assumptions (some of them extremely problematic) about household electricity supply and demand, cooking and heating energy requirements, hydrogen storage capacity, etc.—all determined regardless of household occupants' occupations or locations. Using these specs and "off the shelf" components, the designers demonstrated the technical and economic feasibility of the system and concluded that "the technology is now available to assemble renewable energy systems using hydrogen storage that appear suitable to meet energy needs in such remote locations" (p. 1008).[24] Yet perhaps realizing that what they had done was nothing more than an elegant and sophisticated design paper exercise focused on the technology in exclusion of community participation, they had to acknowledge that

> Prior to remote implementation of such systems, there remain a number of important non-technical matters to consider that are not addressed in the paper, apart from being noted and acknowledged. *Firstly, the needs and wishes of the community are paramount, and should be established at the outset*. This in itself may not be a simple process, but there is clearly no advantage in implementing such systems where they do not meet a felt need. Secondly, where it appears that a hydrogen system may meet a community's needs, *this will only be successful if there is broad community support for and understanding of the new system, which will require a process of engagement, discussion and education*. It must be acknowledged that the detailed design of any system will depend not only on the physical nature of local resources but *also on the outcome of such community engagement;* therefore actual systems implemented may differ from those presented for illustrative purposes here. (p. 1008)[24] [italics added]

While designing a renewable energy system for off-grid rural communities in Bhutan may appear on the surface to exemplify design for social justice, in fact the process followed and the design skills employed more accurately reflect traditional design for technology. The domain of application may be in poor communities in dire need, but the solution itself has not been designed to accommodate the communities' actual contextual circumstances—do they want it, will they be able to support it, and does it even address the problems that arise in their everyday lived experiences?

B. Design for social justice

In stark contrast with the design for technology case described above, a group of engineers from Canada and Australia designed a press to use recycled material collected by garbage pickers in Buenos Aires, Argentina. The phases of their design work are telling. First, mindful of their positions of privilege in academic institutions of wealthy countries, these engineers created Waste for Life (WFL), an organization created "to provide access to scientific knowledge and technology, usually circumscribed by privilege, to people living on society's margins...[and] to open up pathways towards autonomy and genuine economic security for people who need it most—those living at the intersections of waste and poverty."[25] Second, before proposing any technological solution to the problems faced by garbage pickers, WFL engineers analyzed the structural economic conditions affecting the garbage pickers, such as the increasing privatization of garbage management, an economic recession that forced many middle-class people out of their jobs and into garbage collection, etc. Third, still before any technological solution was proposed, WFL engineers conducted a stakeholder analysis to understand the social ecology of garbage collection (including the complex relations between local government agencies, garbage pickers cooperatives, private collectors, etc.) and established a triple-bottom-line approach (economic, human/social, and environmental) to accentuate human/social and environmental dimensions often externalized in economic feasibility studies (p. 6).[26] The above three phases and the one below were informed by on-site, face-to-face interactions with local stakeholders over an extended time period. Lastly, WFL engineers applied a four-step design framework that included: 1) problem identification and acceptance (What is to be solved? For whom is it to be solved? Who will buy into this definition?); 2) critical reflection on implications and consequences of proposed solutions, especially for poor garbage pickers; 3) selection of solutions among a host of possibilities and co-design with key stakeholders; and 4) transformative assessment which challenged engineers to ask, "Have the social injustices facing the garbage pickers been even slightly ameliorated? Have their opportunities been expanded?" (p. 6).[26]

In the WFL design process, a whole series of social-justice oriented concerns were considered before the technology design process commenced, which is opposite the example above, wherein the energy system design is carried out and completed independent of even determining the site of application. Beyond merely "noting and acknowledging" the critically important "non-technical" factors, WFL started with listening to the local context and the structural conditions that shape injustices as they are experienced by local community members. By de-centering the technology in favor of critical reflection upon and intervention within the local context, with social justice concerns at the center, the WFL design team ultimately created a technology—the Kingston Hot-press—but one that responds to its context of application. The Kingston Hot-press processes recycled materials into finished projects (e.g., wallets, watch bands, chairs) that community youth sell to increase their family incomes.

Although the processes leading to the Kingston Hot-press design had social justice at the core, key questions still remain: Is it enough for engineers to position social justice at the core in the steps leading to the design? How do we know if the Hot-press actually contributes to social justice? To answer these questions, we propose criteria that can help us assess the technologies that result from design for social justice practices.

IV. Design for social justice criteria, interfacing with design strategies

We have identified seven emerging criteria for design for social justice, which emerge from literature on engineering design, community development, and social justice. These criteria begin to articulate what components animate the complex, dynamic processes surrounding design for social justice. In this section, we define and identify the origins of each criterion and show how each interfaces with the four design strategies, summarized in Table 1.

A. Listening

Effective listening is vital to the success of all engineering design work, at the outset and throughout the process. But to what or whom do designers listen? Previous research has accentuated that the complexities involved in effective listening are often assumed and not taught to design students.[27,18] Further, a distinction needs to be made between basic and contextual listening.[18] Whereas basic listening "refers to hearing or paying attention to the verbal and nonverbal messages of any speaker" and "is framed as a dyadic process of speaking (output) and hearing/receiving information (input)," contextual listening is more appropriate for community engagement contexts (p. 124).[18] Contextual listening is a

> multidimensional, integrated understanding of the listening process wherein listening facilitates meaning making, enhances human potential, and helps foster community-supported change. In this form of listening, information such as cost, weight, technical specs, desirable functions, and timeline acquires meaning *only when* the context of the person(s) making the requirements (their history, political agendas, desires, forms of knowledge, etc.) is fully understood. (p. 125)[18]

So how do basic and contextual listening relate to each of four design strategies? Listening in design for technology may be constrained. For instance, in one of our research interviews, a former graduate student and current faculty member stated that his undergraduate education and early industry experience taught him that, in design contexts, he needed to "listen to the spec." By that, he meant that he needed to listen to the specifications that were implicit or explicit in the client's explanation of the problem and desired solution. That trained his ear to be a basic listener and to consciously filter out information that did not relate to (mostly technical) specifications. Now, as a design educator, he realizes the disconnect between his early career assumptions about basic listening and the kind of contextual listening required to transcend the constraints inherent in a design for technology strategy, particularly in community engagement contexts.

Contextual listening also relates to HCD for users. In this design strategy, users are primarily envisioned as consumers, so while some listening with empathy is needed, the listening is often focused on solutions to users' desires and needs. Designers assume that the primary mechanism available for providing solutions to users is through a market exchange, and hence their design goal is a commercially available product or service. However, HCD by definition is *human*-centered and solutions need not necessarily be limited to consumer products. Thus, humans can be conceptualized in terms of capacities and needs beyond those strictly related to consumption.

HCD for communities necessitates a shift in listening from basic to contextual for multiple reasons. Contextual listening "facilitates meaning making" in the inherently collaborative learning exchange between community members and designers (p. 125).[18] Among other critical learning outcomes from effective contextual listening, community members learn whether and to what degree they can trust designers. Effective communication is predicated on trust. Without it, community members are less likely to convey their true hopes and aspirations, take ownership by committing themselves to the success of the project, and work together toward solutions that "foster community-supported change" (p. 125).[18] In design for communities, contextual listening becomes a primary mechanism by which designers learn to identify human capacities, needs, and desires, as well as culturally situated human resources, limitations, and opportunities. For instance, a prominent HCD publication reconceptualizes HCD as Hear, Create, and Deliver, with hearing involving phases such as recognizing existing knowledge within the community, identifying people to speak with, and choosing research methods for listening (individual and group interviews, etc.).[4] These listening-centered activities are designed to "collect stories and inspiration" so designers gain a richer understanding of what people in a given community actually desire, a precondition to determining whether their ideas are technically and organizationally feasible and financially viable (p. 8).[4]

Design for social justice necessitates employing a broader array of nuances in contextual listening. Each of the aforementioned factors needs to be part of the listening foci—listening for specifications, for "consumer" desires and needs, for empathy, etc. But richer contextual listening is also required. To enact such listening within design for social justice, designers must develop the ability to listen in ways that help them identify structural conditions that give rise to community needs. While the international and national structural conditions may be ascertainable via research, such generic reading does not give any indication about how those conditions have been experienced *locally*. Although listening to and accounting for structural conditions is crucial to rendering social justice issues visible, those actions alone do not ensure that social justice dimensions will be integrated into the designed solution. Such integration begins when designers *reframe* the problem definition by explicitly accentuating social justice dimensions. As noted in the definition of contextual listening, "information such as cost, weight, technical specs, desirable functions, and timeline acquires meaning *only when* the context of the person(s) making the requirements (their history, political agendas, desires, forms of knowledge, etc.) is fully understood" (p. 125).[18] In design for social justice, contextual listening requires attentiveness to issues generally invisible in the other three design strategies: listening with the express and explicit intention to increase human rights, opportunities, and resources while reducing imposed risks and harms in order to enhance human capabilities. More will be said about each of these issues below.

B. Identifying structural conditions that give rise to needs

What economic, cultural, and other structural conditions gave rise to the needs that a community experiences? This question is often-neglected,[5] but underscores the importance of considering the local, regional, national, and international structural forces that shape the existence of community needs. How do such structural conditions figure into each of the design strategies? The way in which each design strategy approaches such structural conditions exists on a continuum that spans from treating them wholly as background conditions to making them central, active drivers of design processes.

As a rule, design for technology treats social, political, and economic structures as background conditions—as givens that need only be identified but not questioned or, worse, need not even be acknowledged (see, e.g., a widely taught product design text[28]). In fact, we have used the label "design for technology" precisely to highlight that the technology is considered nearly exclusively and largely independent of context.[29] Even as economic dimensions of technology are usually treated as primary constraints, the economic structures that shape cost factors—such as labor rates, energy and raw materials costs, capital availability, etc.—are typically external to the designers' process in design for technology.[5] This is not to say that such structures are not important to how design for technology unfolds, just that the influence is implicit and usually goes unacknowledged.[30]

HCD for users likewise treats structural conditions as givens for the most part. This is particularly true of economic structures, given that the approach taken in HCD for users is usually consumerist or otherwise commercially oriented.[31] A partial exception to this orientation arises when users identify or highlight structural barriers that impede their productivity or otherwise frustrate their "user experience" around a given product, service, or system. In other words, through direct engagement with users, designers may confront structural conditions that users themselves have identified as impediments to their workflow or day-to-day problem solving.[32] Such a confrontation with structural barriers is more likely when designers are deeply empathizing with those who actually are facing those barriers.[17]

HCD for community almost certainly brings to the surface some of the structural conditions underlying communities' needs—most obviously because these conditions directly impact on the opportunities available within the local context—and, hence, as variables requiring consideration by designers.[18] Designers using an HCD-for-community approach may or may not seek to integrate interventions along structural dimensions as components of their design solutions; although such solutions often center on technology, they may extend to include strengthening various structural conditions: social (e.g., organizational, capacity building), economic (e.g., microfinance, market development, barter networks), political (e.g., policy support, local political power sharing schemes), or other dimensions. HCD for community may also explicitly acknowledge some structural conditions, such as, say, cultural assumptions surrounding ethnic relations or gender roles, but seek only to accommodate but not necessarily inflect such conditions in their design work. In both cases, the design process acknowledges some of the salient structural conditions impinging on the local context and shaping both the needs experienced by communities as well as the potential solutions available to address those needs.[33]

As we have defined it here, design for social justice grapples with structural conditions undergirding the problems and challenges communities face explicitly and systematically. That is not to say design for social justice must tackle all structural barriers in the design process, a task that would be impossible, but that the design process includes reflecting on structural conditions and determining which should be incorporated and which not. For example, as was documented by Nieusma and Riley's Sri Lanka case study, renewable energy engineers not only sought to implement community-scale energy systems in off-grid communities, but they also layered in capacity building, so community members were empowered to service the systems; economic reform, whereby formal ownership of installed systems was conferred on a dedicated community non-profit; organizational development, so communities could both effectively manage the newly implemented systems; etc.[5]

C. Increasing human rights

While considering structural conditions is important in making social justice issues visible, it does not by itself guarantee attention to social justice in the design solution, only in designers' heads. To ensure that attention to social justice is incorporated into design solutions, the remaining criteria (C-G) need to be engaged by designers.

Engineering students need to pay attention to how their designs can enhance or curtail specific human rights. Such rights could be those listed in the United Nations' Universal Declaration of Human Rights or in the political constitutions of the nations, regions, or localities for which they are designing. Since most constitutions fall short of protecting all human rights, engineers need to learn that technologies can also legislate. As Langdon Winner writes, "a crucial turning point comes when one is able to acknowledge that modern technics, much more than politics as conventionally understood, now legislates the conditions of human existence" (p. 324).[34] Hence, it is acceptable to design with a legislative purpose: to protect specific human rights.

In design for technology, human rights are likely to be ignored unless clients specifically identify them as critical components and/or outcomes. In HCD for users, human rights may arise indirectly via empathic processes. Human rights in HCD for communities are more likely to be implicitly articulated by multiple stakeholders, particularly community members as they express their needs, desires, and aspirations. In design for social justice, human rights are a standard, critical component, which acknowledges both the universal and cultural/contextual nature of rights, and challenges designers to explicitly focus on design ideas that increase human rights. In that process, designers should ask, "Whose human rights are augmented—and how?"

D-F. Increasing opportunities (D) and resources (E), reducing imposed risks and harms (F)

Since the need to fairly distribute opportunities and resources and to reduce imposed risks and harms are all explicitly identified as part of our field-tested definition of social justice, they are combined here into a single section. Our definition emerged by taking a well-established definition of distributional social justice (p. 18),[7] which led many of our students to ask the question, "What are the distribution of resources, opportunities and the reduction of risks and harms for?" Adopting Nussbaum's Human Capabilities approach to social justice, we are able to answer our students and challenge them to develop designs that are socially just in order to enhance human capabilities (see criterion G below).

To reiterate, in engineering contexts, we define social justice as engineering practices that strive toward an equitable distribution of **opportunities and resources** in order to **enhance human capabilities** while **reducing the imposed risks and harms** among the citizens of a society.[7,8,9,10]

The distinction between opportunities and resources becomes clearer via example. If students are asked to design a ramp for persons with disabilities, for instance, the ramp can enhance opportunities for such persons to access public buildings for education, literacy, recreation, and more, but only insofar as users have the resources necessary to make the ramp relevant, e.g., wheelchairs. In addition to the physical barrier imposed by inaccessible stairs, persons with physical disabilities can also face attitudinal barriers to their presence and full participation, which can result in the social harm of exclusion, curtailing of their participation, and more. We discuss the human capabilities component of our definition in more detail in the next section.

As noted above, in design for technology, the client largely conceptualizes and defines the problem, and then provides designers with specs related to cost, function, time-to-delivery, and (sometimes) manufacturability. Thus, opportunities, resources, risks, harms, and human capabilities are likely to become part of the problem definition and solution only if the client explicitly identifies them as critical parameters. Otherwise, they will most likely remain invisible and only implicitly addressed in both problem definition and solution. It merits reiterating that all technology—and hence design—serves some interests over others—that whether or not it is made explicit, technology design provides opportunities and resources for some, and contributes to increased risks and harms, usually for others.[35]

The risks and harms we refer to here are those imposed on others unwittingly, not risks knowingly assumed by products' users. All people take risks of some sort everyday. We are not concerned with risk-taking per se, but with the imposition of risks by some people upon others. Sometimes, such imposed risks are *direct*, even if unintentional, as in the case of development interventions that commit beneficiaries to on-going debt repayment schedules that are not gauged to wide income fluctuations seasonally and over years. At other times, the imposed risks are *indirect*, a consequence of larger structural conditions that designers operate within, such as likelihood of development interventions to *increase* inequity among competing social groups within the local context, even while uplifting the average standard of living of the targeted beneficiaries.

In HCD for users, empathy for users may lead to greater understanding of particular risks and harms as well as the specific kinds of opportunities and resources necessary to overcome them. Although the same may hold true in HCD for community, that strategy is more likely than the first two design strategies to yield additional data related to opportunities, resources, risks, and harms. If a contextual listening framework is adopted, better data will emanate from several processes inherent in HCD for communities: 1) investigating the socio-economic, historical and cultural context where communities live, work, and will use a design, 2) identifying cultural differences and sources of ambiguity, 3) building relationships with community members, 4) acknowledging and minimizing deficiencies while recognizing capacities, 5) foregrounding self-determination, and 6) working toward shared accountability.[18] Grounded in contextual listening, the main goal of HDC for communities is to accommodate and enhance any culturally situated human opportunities and resources, while attempting to minimize risks and harms.

In our criteria on design for social justice, a contextual listening framework is also at work, so the same six processes described above apply. However, social justice dimensions inherent in the design that might otherwise be invisible will more likely surface for several reasons. First, designers for social justice have built in explicit investigation into the structural conditions that give rise to extant inequalities; awareness of such inequalities may emerge via contextual listening or paying attention to means of increasing human rights. Such investigations often unearth risks and harms, and may also reveal otherwise masked opportunities and resources. Second, designers for social justice consciously explore opportunities to enact the aforementioned definition of social justice. Doing so makes them highly attentive to how opportunities, resources, risks, and harms shape problem definition and the entire recursive design process. How do designers investigate structural conditions that lead to inequality and explore chances to enact the definition of social justice in practical contexts? One answer to that question appears in the ramp design problem described below.

G. Enhancing human capabilities

In theory, all engineering work enhances human capabilities. In practice, however, enhancing human capabilities can be de-emphasized or highly implicit in the engineering design process—and outcome. And it matters considerably whose capabilities are being enhanced in practice and to what end. As historian David Noble famously pointed out, industrial automation engineers in the 1970s sacrificed overall production efficiency in support of management efforts to exert greater control over labor.[36] Our emphasis on human capabilities stems primarily from the work of Nussbaum, who has positioned 10 central human capabilities[37,10] in a capabilities approach designed to evaluate human progress in development contexts.[38] (Both economist Amarta Sen[39,40] and Nussbaum are credited with laying the foundation of the capability approach, but our work draws most substantively from Nussbaum). Nussbaum's work is rooted in social justice questions, where the capabilities serve "as a benchmark for a minimally decent human life" (p. 22).[10] She recognizes that "all rights, understood as entitlements to capabilities, have material and social preconditions" (p.

21).[10] Research applying the capability approach to technology and design has emphasized that

> According to the capability approach, a key evaluative space in these areas [justice, equality, well-being, and development] is not income, not resources, not primary goods, not utility (i.e., happiness or the sum of pains and pleasures) or preference satisfaction. Its proponents argue that the focus should rather be on human capabilities. Capabilities are often described as what people are effectively able to do and be or the positive freedoms that people have to enjoy valuable 'beings and doings.' (p. 4)[1]

Rather than focus on a hierarchy of needs and what people lack or basic conditions for survival, Nussbaum emphasizes that human capabilities include *life* (of a normal length); *bodily health*; *bodily integrity* (including freedom from violent assault and the ability to move about freely); *senses, imagination, and thought* (the use of which are critical to being fully human); and *emotions* (including love, grief, longing, gratitude, and justified anger). Capabilities also include *practical reason* (for critical thinking, freedom of conscience, and religious observance) and *affiliation* (both protecting institutions that foster human compassion and ensuring the social conditions for self-respect and non-humiliation regardless of sex, ethnicity, sexual orientation, etc.). Finally, the 10 capabilities are completed by *other species* (including how we respect and interact with plants, animals, and all of nature); *play* (recreation, laughter); and *control over one's political and material environment*. In all cases, the capabilities approach highlights the value of protecting social institutions and conditions that promote and enhance each capability or multiple capabilities.[37,10] For Nussbaum, social justice is not just for a more equitable distribution of resources (i.e., distributive justice), but the main goal of social justice is to enhance human capabilities (i.e., transformative justice). As noted elsewhere, "the capability approach conceptualizes well-being in terms of a person's capabilities and development as a process of expanding these capabilities" (p. 5).[1]

In design for technology, some human capabilities are likely to be assumed as givens, such as *life* of a normal length and *bodily health*. Those capabilities align broadly with the engineers' ethical mandate to "hold paramount the safety, health, and welfare of the public."[41] However, other capabilities will be emphasized only in cases wherein the client explicitly identifies them as crucial outcomes. For instance, if a playground client expressly accentuates the goal of *affiliation* (ensuring playground equipment that fosters self-respect and non-humiliation) and the goal of interactive *play* (among individuals of various physical abilities), the rights and capabilities of individuals with a wide range of (dis)abilities will likely be accounted for in the design solution. Absent such explicit constraints, the design for technology will likely lack such capability-enhancing dimensions. Although in theory engineering design students could identify and develop an understanding of such constraints, in our past experiences observing senior design teams, they tend to follow client-provided constraints and remain somewhat passive about introducing constraints that might be "outside" the range of client awareness—unless design instructors explicitly foreground the importance of identifying such constraints.

In HCD for users, human capabilities could be ignored, but could also matter on two levels. On a practical level, designers seek to know users' *senses, imagination, and thought* as well as *emotions* to design products, services, and more that are tailored to users' needs, aspirations, habits, and more. Yet as noted above, on a deeper human level, designers are encouraged to empathize with users.[17] The critical question here is this: designers need to empathize *with what dimensions* of the user experience? Certainly this will depend on the nature of users' expressed desires, but one can see how, among others, *bodily integrity, practical reason, affiliation, emotions, play*, and *control over one's environment* could be highly relevant to HCD for users.

In HCD for communities, human capabilities can play a central role. The connections between the capability approach and design have seen a surge of interest of late.[2,42,43,44] Much of this research focuses on design for developing communities, and articulates a perspective in which effective design is expressly intended to enhance human capabilities. Some authors accentuate a "conception of design as being about creating the opportunities for living valued lives [that] is consonant with several of the central capabilities on Nussbaum's list" (p. 194).[2] For instance, enhancing *senses, imagination, and thought* is "linked both to the activity of ideation in design but also the outcome of designing" (p. 194).[2] Also, *control over one's material environment* and *practical reason* "are essential to the design activities of defining objectives and requirements and their evaluation in alternative solutions" (p. 194).[2] The authors point out that Nussbaum's idea on *practical reason,* as having the capability to "form a conception of the good" (p. 79),[45] is "entirely consonant with the observation that designers 'bring their own intellectual program with them into each project' (p. 137)[46] to advance the designer's vision of what the world should be like" (p. 194).[2]

The primary difference between the capability approach in HCD for communities and design for social justice is that, in the former, the capability approach is integrated only in those instances in which designers are aware of the approach. By contrast, in our articulation of design for social justice, the capability approach is a core criterion; enhancing human capabilities serves as an explicit, central goal in the process and outcome of design. That said, we are the first to admit that, at first, the questions that are raised by integrating human capabilities in design seem overwhelming in complexity. Such questions are difficult and raise issues that are sometimes impossible to evaluate empirically, and they remain dynamic and nuanced—yet vitally important. As briefly mentioned above, renewable energy engineers in Sri Lanka sought not just to implement new energy systems, but to build capacities among community members—technical, financial, managerial, and organizational. They did this not only to assure the systems were "sustainable"—that is, functioning over years, not months—but also so that the designed intervention was fully "integrated," including not only a functional technology, but also one that was adapted to the community's interests and understandings and one that brought community members in so that they could be partners in creating and leaders in maintaining the systems over time.

Table 1 summarizes how each of the four design strategies addresses the seven design-for-social-justice criteria.

Table 1: Design for social justice criteria interface with design strategies

	Design for Technology	HCD for Users	HCD for Communities	Design for Social Justice
A. Listening	Basic listening, to the client but often really "to the spec"	Basic but if robust empathy activities are integrated, moving toward contextual	Contextual listening	Nuanced contextual listening
B. Identifying Structural Conditions That Give Rise to Needs	Structural conditions serve as background constraints, but are generally ignored by designers	May glimpse structural conditions in the process of empathizing with users, but not treated explicitly or systematically	Structural conditions play significant role in shaping local context, which designers elicit through community engagement	Advance capacities, needs, and desires in sustainable way by helping community members identify and respond effectively to the structural conditions that impinge upon them
C. Increasing human rights	Generally ignored	Could emerge indirectly via empathy	If present, often articulated indirectly by community members	A critical component of design and treated explicitly
D. Increasing opportunities	Only for those who can afford the final product	Only for those who can afford the product, but empathy may lead to designs that increase opportunities	Contextual listening results in designs that accommodate and enhance culturally situated opportunities	An explicit goal informed by the processes inherent in criteria A-D and via heeding social justice (E-G)
E. Increasing resources	Only for those who can afford final product	Only for those who can afford the product, but empathy may lead to designs that increase resources.	Contextual listening is aimed at identifying which resources need increasing.	An explicit goal informed by the processes inherent in criteria A-D and via heeding social justice (E-G)
F. Reducing risks and harms	Viewed primarily in terms of liability	Viewed in liability terms, but empathy may lead to designs that reduce other risks and harms	Contextual listening process identifies risks and harms so they can be mitigated	An explicit goal informed by the processes inherent in criteria A-D and via heeding social justice (E-G)
G. Enhancing human capabilities	Generally ignored or in a few cases assumed as givens	Generally ignored unless capabilities emerge in design specs or in the empathy process	Can play a central role, if the capability approach is known and used	An explicit, central design goal

V. Design courses interface with design for social justice criteria

Table 2 summarizes how each criterion in design for social justice intersects with three examples of engineering design instruction. The three courses include: 1) a human-centered problem definition course, part of the Humanitarian Engineering Program at the Colorado School of Mines, 2) a participatory design studio course, part of the Programs in Design and Innovation at Rensselaer Polytechnic Institute, and 3) a first-year design course in the biological engineering program at Louisiana State University. These three courses are not taught by any of the co-authors of this paper, and in each case, the instructor had an opportunity to review the course descriptions in our paper, which were informed by background knowledge, informal conversations, and/or formal research interviews using IRB-approved consent forms. All three course instructors responded to the author-provided descriptions with (minor) comments, which were then integrated into the paper.

Table 2: Design for social justice criteria in three design instructional contexts

<table>
<tr><th></th><th>Human-Centered Problem Definition, HE Program, Colorado School of Mines</th><th>Participatory Design Studio, Programs in Design Innovation, Rensselaer Polytechnic Institute</th><th>Biology in Engineering Course, Biological Engineering, Louisiana State University</th></tr>
<tr><td>A. Listening</td><td>Contextual listening to individuals and to communities; activities include listening to self and to multiple others affected by design. Also, identifying all potential “affectees” of a design, and to go listen to a selection of them.</td><td>Basic and contextual to users as they reflect on their personal, educational, and cultural experiences, needs, and desires.</td><td>Basic and active contextual listening to ascertain and design for the “soul of the community” via a three-part interaction-reflection-action process.</td></tr>
<tr><td>B. Identifying Structural Conditions That Give Rise to Needs</td><td>This may occur indirectly, subtly via shadowing and other activities.</td><td>Part of systematic background research carried out by design teams.</td><td>Occurs implicitly via contrasting public vs. private education, transcending privilege guilt, and contextualizing integration/segregation by understanding trajectory since Brown vs. Board of Education.</td></tr>
<tr><td>C. Increasing human rights</td><td>Not explicitly integrated, but this may arise via empathy-building activities.</td><td>Not explicitly integrated, but arises indirectly through assessment of educational structures in place in the local, state, and national contexts.</td><td>Can emerge from reflecting on the question, “What is the role of an engineer in a democratic society?” Also can surface via ability and geographic-related accessibility issues.</td></tr>
<tr><td>D. Increasing opportunities</td><td rowspan="3">Via multiple activities, human-centered design specifically aims to facilitate understanding of the ways in which design can increase opportunities and resources as well as decrease risks and harms.</td><td rowspan="2">Increasing opportunities and resources is targeted directly through creation of new educational experiences and tools and indirectly through educational advancement.</td><td>Increasing opportunities for accessibility, ownership, and play.</td></tr>
<tr><td>E. Increasing resources</td><td>Almost 30 playgrounds constructed to date.</td></tr>
<tr><td>F. Reducing risks and harms</td><td>Means of reducing risks and harms is not explicitly integrated, but arises indirectly through educational advancement.</td><td>Occurs via confronting safety and liability issues and designing to decrease social/emotional conflicts.</td></tr>
</table>

G. Enhancing human capabilities	This is an overarching, aspirational ideal for HCPD that grows from a seed: identifying what constitutes a need and the type of need, and later how people experience that need (via shadowing, etc.) and from case studies of empowerment via designs that enhanced community members' capabilities.	This is the overarching goal of the course—to enhance capacity of users through STEM education approaches and technologies that are culturally responsive.	This is an overarching goal and outcome of the course, and multiple capacities are engaged in important ways. Capacity building focuses on both university design students and all community partners, particularly elementary school students.

A. Human-centered problem definition

Human-Centered Problem Definition (HCPD) is an engineering-by-doing course in the Humanitarian Engineering Program at the Colorado School of Mines. Part design and part problem definition course, it was designed in Fall 2013 and debuted in Spring 2014. In terms of its course objectives and instructional activities, HCPD engages the design-for-social-justice criteria variously, ranging from directly and explicitly to indirectly and implicitly.

Contextual listening is directly engaged in HCPD, and occurs in terms of listening to individuals (users and others affected by a given problem and solution) and to communities. Learning how to listen to communities emerges from case studies. Some cases are drawn from the lead instructor's lived experience, working with International Development Enterprises (IDE) and in India. These case studies show the means by which IDE engages communities, including which stakeholders (by gender, social position, etc.) play key roles as IDE learns about community values and concerns. Since development of listening skills is a primary learning outcome, course activities are structured to teach students first to listen to themselves (developing intrapersonal awareness of how each student identifies and defines problems) and then to listen to others (using not just their ears but all their senses), with the aspirational goal of doing so in a relevant, unbiased manner so that the perspectives of all those affected by the problem and/or solution are heard. The lead instructor indicated that her students learn important differences between how to listen to individuals and communities.

The above discussion tells to whom students learn to listen, but not for what purposes they are listening. One of the primary learning objectives is to be able to understand others' needs and desires. To achieve this objective, a series of activities is designed to move students temporarily out of their own experiences, assumptions, and frames of reference, so they can more fully empathize with people affected by a given problem and solution. For instance, students create a "Bug List" of (not computer glitches but) issues that disturb them and others, as well as opportunities for improvement. They later categorize that list according to importance, relevance to specific societal groups, and a spectrum moving from narrow to broad in terms of personal and social impact. Then they look at others' lists and rankings, which helps them realize that their own rankings are not universally shared. Also, in comparing lists, students realize that there are multiple ways to define a problem, and that the framing of problems shapes how designers explore solutions. Another example involves students learning how to articulate and address their own needs and desires before extrapolating to others; that extrapolation occurs by exploring whether others have the same needs and desires. The activity is designed to put in check a problem solver's instinct to dive right into the solution before fully understanding the nature of the problem from multiple perspectives.

Indirectly, students explore the structural conditions that give rise to people's needs. For instance, students might identify telling time as a need, but a $500 Rolex as unnecessarily extravagant to fulfilling that need. Structural conditions are unearthed subtly. For instance, students shadow others (ambulance EMTs, etc.) to try to identify problems and opportunities that arise in their daily experiences. That observational data might begin to unveil structural conditions. Also, students contrast a short-term lived experience (being in a wheelchair, being blindfolded, having their hearing temporarily impaired), and their reflections on problems that arise, with the problems identified by guest speakers who spend most of their day in a wheelchair, or who are visually or hearing impaired. Such contrasts help them develop a keener sense of user empathy, and a keener eye for human-centered design, and may reveal structural (economic, cultural, etc.) conditions that give rise to human needs.

Although teaching students about human rights is not an explicit learning objective, it may arise in the course via user empathy processes. In particular, many of the IDE case studies in the course involve conditions of injustice within communities, and the instructor wanted to present those cases and see if students identified human rights abuses or issues. The aspiration was that students would ask what contextually appropriate design processes best facilitate solutions that address injustices.

Since the course is focused on human-centered design, it specifically aims to facilitate understanding of the ways in which design can increase opportunities and resources as well as decrease risks and harms. Students are asked to recognize such design components from multiple activities, including the aforementioned shadowing activity and the activity involving an initial short, lived experience (blindness, deafness, etc.) and conversation with people who experience such issues regularly. The instructor asks students to identify and categorize the kinds of problems they experienced with those of others, and challenges them to use that information to design in ways that increases opportunities and resources and decreases risks and harms.

Finally, enhancing human capabilities is an overarching, aspirational ideal for human-centered design. The instructor indicated that that broad learning outcome grows from a seed: identifying what constitutes a need. The seed grows when students learn how people experience that need (via shadowing, etc.) and from case studies of empowerment—of designs that enhanced community members' capabilities.

B. Participatory design studio

The Participatory Design Studio course is part of the Programs in Design and Innovation (PDI) and Design, Innovation, and Society major at Rensselaer Polytechnic Institute. PDI combines engineering, social sciences, business, and design through a sequence of interdisciplinary, problem-based design studios. The Participatory Design Studio is the fifth in that sequence and is enrolled predominantly by third-year students. The course was created by, and for many years has been taught by, a Science and Technology Studies Professor. The course focuses on PDI students collaborating with targeted user groups, whose geographic, cultural, or economic positions are notably distinct from those of most Rensselaer students. The longest-term collaboration has been with a local community charter school designed to serve "at-risk students." The analysis below follows this collaboration.

In the Participatory Design Studio, students embark on Community Technology Design projects,[47] including developing STEM educational tools for the charter school students. These projects require both basic and contextual listening to users as they reflect on their personal, educational, and cultural experiences, needs, and desires. PDI students meet with and observe these users at various stages of the design process: during problem formulation, to test concept mock-ups, and to test initial design prototypes. Through these interactions, PDI students grapple with formulating and then addressing the "design problem" in a way that resonates with the lived experiences and worldviews of the charter school's students. As with the Biology in Engineering course described below, trust between the PDI and charter schools students is imperative if the overall process is to be a successful learning experience for both groups, which is true regardless of the ultimate success or implementation of the designed objects.

In the STEM educational tool design process, PDI students review a range of structural conditions that give rise to educational inequities, not least including the long history of under-representation of racial and ethnic minorities as well as women across STEM educational programs and careers. Structures of racism, sexism, consumerist innovation, and cultural individualism are all considered as relevant inputs to the students' design process, and they are encouraged to carry out background research into those dimensions as a means of designing for the bigger picture of STEM education inequities. PDI students are also taught to question some of the conceptual structures that underpin many intervention schemes, particularly around the "deficit model" of education (and development).[48] The deficit model explains the problem of underachievement according to supposed deficiencies existing among the targeted students or their families/cultures, rather than by looking at the social, political, and economic structures that contribute to the failures of entire school systems and educational policy frameworks.

Questions of human rights are integrated into the Participatory Design Studio course as well. For example, such questions arise explicitly via critiques of authoritarian versions of socialism like those surrounding the creation of technological infrastructure in the early U.S.S.R.[49] Additionally, questions of rights arise indirectly through consideration of structural inequities surrounding U.S. educational policy, as discussed above, as well as surrounding educational resources and achievements that exist at local, state, and national levels.

The Participatory Design Studio seeks to increase opportunities and resources both directly by providing new educational experiences and, ideally, tools, and indirectly by advancing charter-school students' on-going opportunity structures through heightened STEM educational achievement. By starting with a critique of the deficit model of education, PDI students are primed to rethink the types of resources that ought to be increased. As the course instructor pointed out, students move beyond the "deficit model, which can be patronizing and foster concepts of dependency. Students in the class work towards an understanding of how to help groups re-discover or re-invent or re-purpose their own cultural capital" (personal communication, Feb. 13, 2014).

The structural approach to understanding STEM educational inequities taken in the Participatory Design Studio helps PDI students recognize how designers often unintentionally impose (or contribute to the imposition of) risks and harms on certain stakeholder groups. In a non-trivial sense, the entire project is motivated by the goal of reducing the risks and harms imposed upon marginalized communities as a result of pervasive educational inequities as well as the cultural and economic biases built into mainstream educational approaches, not to mention educational (and developmental) assistance models. That said, the extent to which PDI students seek to anticipate the long-term potential risks and harms that could be created by the implementation of their design solutions is less clear.

As an educational intervention, the Participatory Design Studio STEM educational tool project is motivated by the goal of enhancing human capabilities in a fundamental sense. By improving STEM educational approaches and technologies in ways that respond directly and immediately to the lived experiences and cultural values of the targeted users, PDI students are taught to strive to empower users on their own terms. Nevertheless, the students also explore the tension between a shorter-term user-centric approach—"giving users what they want"—and a designer/design-goal-centric approach of optimizing a particular outcome, in this case educational achievement. In this way, they seek to move beyond redistributive justice and toward a "more generative justice approach."[50] The concept of generative justice resonates with Nussbaum's concept of transformative justice recounted above, but highlights the potentiality of design to create entirely new opportunity structures that might enhance human capabilities in systematic and enduring ways.

C. Biology in engineering

In the Biological Engineering program at Louisiana State University, Biology in Engineering is a first-year design course in which "students learn about engineering, biological engineering, design and themselves." The course also helps them "determine if biological engineering is an appropriate major," helps them "sharpen communication and teaming skills," and encourages "civic responsibility" (p. 258).[51] Students design a playground for public elementary schools in the Baton Rouge area. Like the two courses above, the social justice criteria are engaged directly and indirectly, explicitly and implicitly.

Listening is an explicit course objective, so the course features specific instruction in active listening that underscores the crucial role of earning trust. The instructor indicated that her students cannot learn about play from just listening to and observing children on a playground; they also need to talk to students who trust them. Hence, they spend eight weeks tutoring one student in math or reading, and in the process get to know the principal, teacher, school culture, and that student. Once they have earned the student's trust, they are better prepared to learn about each student's ideas on play. So listening is part of a three-part iterative process in which university students a) interact with multiple community partners in the school community, b) formally reflect on those interactions, and c) investigate and act on how those interactions and reflections inform their playground design. The overarching goal is for students to design a playground that, in the instructor's words, "reflects the soul of the community." Although students initially do not fully appreciate what tutoring a student has to do with engineering design, they generally finish the course recognizing that their interactions within the school community and their reflections clearly informed and improved their design choices.

Although a quite implicit course objective, discussions of structural conditions that give rise to student needs inevitably surface in the learning process. For instance, almost all the university students hail from K-12 private schools, and they often hold preconceived views about the low quality of public schools and their students. Those views change as they see that the students and entire public school community work hard but mostly lack resources. When the first playground was designed in the late 1990s, the instructor immediately received a call from another school principal interested in a playground, and that pattern has repeated; to date, almost 30 public school playgrounds have been not just designed but also constructed. Conversations about structural conditions arise in two other course contexts. Students from privileged backgrounds frequently take for granted the playgrounds and other resources they grew up using in private schools, so they sometimes need to address, reflect on, and learn to move beyond a sense of guilt regarding their own privilege, especially if they regard play as a right and not a privilege. Also, students learn about how the 1954 Supreme Court decision in Brown vs. Board of Education influenced racial integration, to put in context the realities they observe in visits to the public schools. When structural conditions come to the forefront, students are encouraged to ask, "What can we do to address these conditions in our design?"

Although design that increases human rights is not explicitly on the syllabus, it arises organically from the course foundations. Those foundations remind students that engineers need to ask, "What is the role of an engineer in a democratic society?" Of all human rights, the one most explicitly engaged is accessibility, in two forms. First, students learn to address Americans with Disability Act accessibility requirements and ensure that playgrounds promote interaction among students of multiple physical and cognitive ability levels. In short, students must be able to design for access. Also, students encounter geographical access issues, particularly since many students live over a mile from a playground (which may be unsafe to walk to), so their entire or primary playground access may be at school.

In Biology in Engineering, the university students use design to increase opportunities. In addition to the aforementioned accessibility opportunities, university students also promote opportunities to develop student and school community ownership. In fact, developing relationships facilitates a broad range of opportunities that would likely otherwise be impossible. For instance, at the groundbreaking ceremonies for the playgrounds, many students voice a strong sense of ownership of the future playground, because they got to know the designers and because all the team designs are hung in the school so students can vote on which design components they prefer. Those votes inform the final selected design, so students feel they own a part of that design. Also, students have penny drives to help fund construction costs, and they contribute what they can, which fosters ownership and pride. Besides accessibility and ownership opportunities, students also promote the opportunity for play, which promotes health, fun, creativity, and imagination via an appropriate playground design.

Although increasing resources is not an explicit course component, it nevertheless occurs in two ways. First, university students have the option to write either a final report on their design or a proposal to an organization, in hopes of gleaning funds to construct the playground. Post-course, such funds as well as funds from other sources enable the instructor to pay a smaller number of students who take the final design to construction and completion. Resource increases also occur in the most obvious fashion: the day the kids can finally play on their new playground, they own a carefully designed, fairly durable community resource.

Reducing risks and harms is part of the course in both highly and moderately explicit ways. Students confront safety and liability issues head on. Since playground design is the second most common reason young students go to the emergency room in the U.S., according to the instructor, designers look for multiple mechanisms to increase safety (and to decrease their liability). Still explicit but less so, students also inquire into school playground contexts and ask several site-specific questions: How might our playground design decrease bullying? How might our design disturb foot traffic patterns to break up kids who always stay in the same groups, or who are often alone, or who yearn for interaction? What kinds of fun social and emotional interactions could our design facilitate that are not happening now or that could be augmented?

Prior to being asked about capabilities, the course instructor identified several of the capabilities specifically. For instance, she specifically pinpointed the connections between *play* and *bodily health* but also between *play* for enhancing *emotions* and for developing *senses, imagination, and thought*. In her observations of children at play, she also noted how often interpersonal conflicts are solved creatively, empathically, and with respect—a fine example of *affiliation*. Also, in providing input on their design preferences and via fundraising, students were in some ways taking *control over their political and material environment.* Beyond the elementary school students, capacity building was a focus for the university students as well. For instance, via the three-part listening process, they were able to not just understand how community desires and aspirations translated into the material design, but were also able to reflect on *practical reason*, particularly by exploring their designs vis-à-vis the broader question of the good engineers can do in a democratic society. Overall, the course focused on building a variety of capacities for both the university design students and all school community partners, in particular students.

VI. Implications, lessons learned, and conclusions

What are the implications of design for social justice for community engagement contexts? That question might be best addressed via an example, as an example can underscore the shift in design thinking we are proposing via the criteria. If designers for social justice were asked, for example, to improve physical access to educational and other opportunities, what kinds of questions would they explore? A robust, integrated approach would begin by identifying major barriers to access, as described in Figure 1.

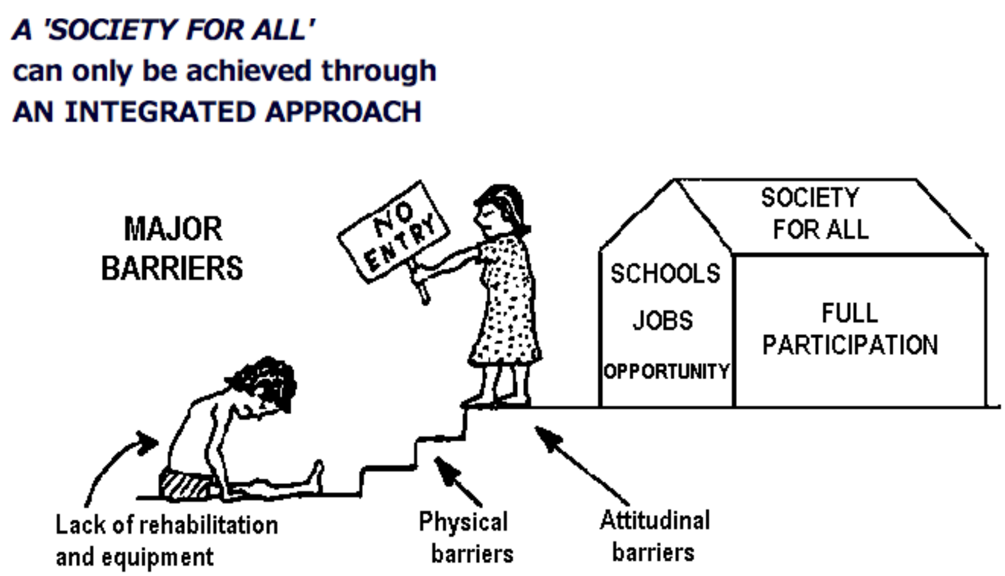

Figure 1: Identification of major access barriers to socio-cultural opportunities, resources, and capability enhancement.

Figure 1—along with Figures 2 and 3—is taken from the Program of Rehabilitation Organized by Disabled Youth of Western Mexico (PROJIMO), an organization dedicated to design with communities for their members with disabilities. Their problem definition phase includes an understanding of the elements of design for social justice, as described below. Furthermore, a design-for-social-justice approach seeks an integrated solution and not the kind of partial solutions seen in Figure 2.[52]

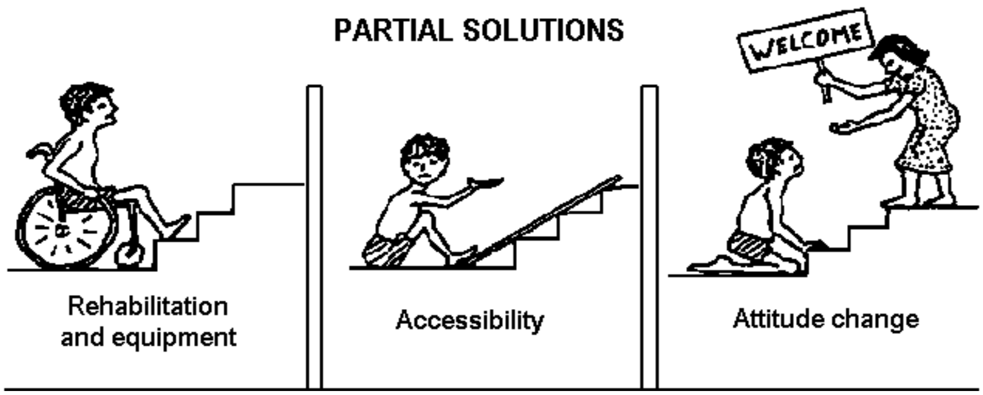

Figure 2: Partial solutions result from partial (non-integrated) problem definitions

If design for technology or HDC for users strategies lead engineers to only design a wheelchair or a ramp, the teacher could still deny access to education. By contrast, in design for community and for social justice, the attitudinal barriers are integrated as explicit components in the design problem definition, along with other sociotechnical components. If policy solutions alone lead to attitudinal changes, the boy may still need a wheelchair, physical therapy, and a ramp. Thus, design for social justice calls for an integrated approach, explicitly incorporating a wider array of sociotechnical components in the problem definition and solution phases and systematically seeking to direct them all toward a social-justice goal. The specific array of components requiring attention emerges via inquiry into the criteria for social justice as described above. An integrated solution is depicted in Figure 3.

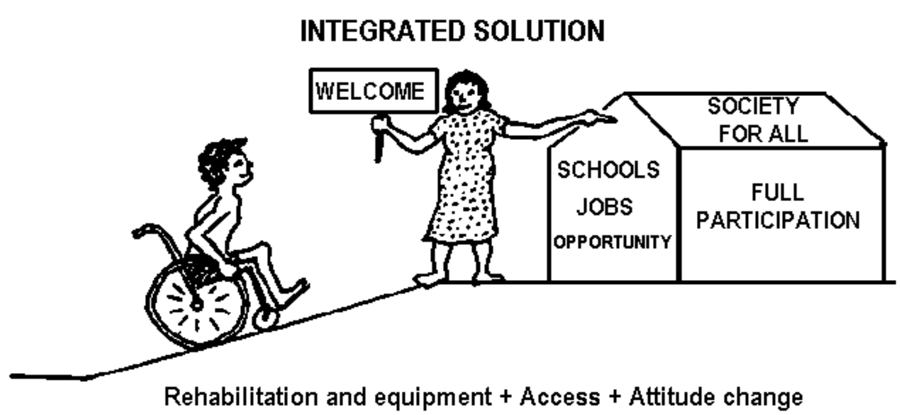

Figure 3: Integrated solution to sociotechnical access barriers results from integrated problem definition phase and design-for-social-justice strategy.

Design-for-social-justice solutions are integrated, taking into consideration multiple criteria. For instance, the process of **identifying structural conditions that give rise to needs** arises when the designers explore what economic, cultural (attitudinal and beyond), and other major and minor barriers exist to ensure fair and equal access. This process involves contextual **listening**. Attitudinal barriers by the teacher represent a denial of a **human right**: equal access to education. Physical barriers within the terrain and infrastructure represent for some students a denial of **opportunities**, including better job possibilities, higher income, etc., that require education (a public **resource** usually intended to **enhance human capabilities**). The lack of rehabilitation and equipment also represent a lack of **resources**, e.g., therapy, wheelchairs, etc. Design for social justice also occurs as designers consider possible design components that will best **reduce the risks and harms imposed** upon some people that preclude them from developing their talents and capabilities. However, the overarching purpose is to **enhance human capabilities**, which in this case includes bodily health, bodily integrity, emotions, affiliation, senses/imagination/thought, play, practical reason, and control over one's material and political environment.

From investigating the question, "What is design for social justice?" several lessons have emerged. One of the key lessons learned from the interface of social justice criteria with the four strategies is that each strategy places value on different components of the design process and outcome. As leaders in community engagement in engineering design have reminded us, "Design process optimization is part of the value you [engineering student designers] are providing to the community. If you neglect to identify *key design issues*, it may require a redesign or modification that may extend past your course and make delivery difficult or impossible…" (p. 52).[51] We italicized "key design issues" above because that phrase raises important questions: What are the key design issues when problems are identified and defined according to design for technology, HCD for users, HCD for communities, and design for social justice? That is, what key design issues surface within each design strategy? Clearly, design is not a value-free enterprise; each of the four design strategies contains normative dimensions and accentuates particular values, each with its own consequences. For instance, the valuation of cost, function, time-to-delivery, and client-invoked specs alone places some key design issues at the foreground and others—including explicit consideration of social justice criteria—in the background. The same emphasizing and de-emphasizing of key design issues occurs for the other three strategies, but, generally, each successive strategy includes the values of the former, even if implicitly. Our definition of design for social justice incorporates key issues from each of the previous strategies: for instance, cost, function, time-to-delivery from design for technology; ergonomics, esthetics, and empathy from HCD for users; and socio-economic and cultural contextualization and contextual listening from HCD for communities. Where design for social justice differs is that it also explicitly incorporates the critical dimensions frequently missing or less fully developed in other design strategies: identifying structural conditions that give rise to needs; increasing human rights; increasing opportunities and resources; reducing imposed risks and harms; and enhancing human capabilities.

Another crucial lesson learned has emerged from the process of integrating social justice criteria into design. Design for social justice does not exactly add additional constraints to design processes; instead, it *renders visible* the constraints that are *already inherent* to design processes but are frequently omitted or underemphasized. The reasons why such constraints are omitted or underemphasized is a focus of two authors' forthcoming research, which identifies the mechanisms by which veils of awareness can be lifted so social justice dimensions *inherent to the design process* can be thoughtfully integrated.

An additional lesson learned centers on which form of justice surfaces in design ethics. Over the past 10 years, Joseph Herkert has been challenging engineering ethics to move from considerations of mostly micro ethical issues—research integrity, regulatory compliance, conflicts of interest, etc.—to considerations of macro ethics.[53] Macro-ethics issues are those that produce broad, negative social impacts, such as systemic social inequities, environmental degradation, or other externalized costs on unwitting stakeholder groups. Macro-ethical issues are inherently social justice issues, as they include larger socio-cultural and structural dimensions. But what form of social justice serves as the most apt framework for engineering design ethics? The design-for-social-justice criteria, particularly as they draw from the capabilities approach, suggest one response to this question. The capabilities approach accentuates that social justice is not just for a more equitable distribution of resources (distributive justice), but the main goal of social justice is to enhance human capabilities—that is, transformative justice. Research into the broader significance of highlighting the role of transformative justice for technology and design is emerging with promising new insights (e.g., see[54]).

While the capabilities approach holds promise, it also holds limitations, another lesson learned. Nussbaum's 10 capabilities are not universally agreed upon, as different cultures define and prioritize capabilities differently. Also, as Oosterlaken has observed,

> One of the many challenges is also that it is hard to measure capabilities, as they (a) refer to the possible and not just to the realized and (b) are a complex construct depending on both an individual's internal characteristics/capacities and his/her external environment. A challenge is furthermore how to 'aggregate' over people while not loosing sight of the fact that a capability approach emphasizes that each and every person needs sufficient capabilities to lead a flourishing life. Another topic of discussion has been whether or not the capability approach, with its emphasis on an individual's capabilities, is not too individualistic and pays enough attention to groups and social structures…. (p. 6)[1]

Further research into these limitations—and innovations on how to address them—is warranted.

Another lesson learned, which emerged from interviews and conversations with design faculty, is that the criteria we have proposed sit at the center of an evolving debate regarding engineering design education. It can be argued that the design-for-social-justice criteria introduce excessive ambiguity and throw engineering student designers into highly unfamiliar interdisciplinary terrain. Intriguingly, this claim can be used as a basis *both for and against* integrating the criteria in design-for-community-engagement contexts. Opponents of integration emphasize that design is already among the most ill structured of activities in the engineering education curriculum, and that adding the criteria only introduces additional layers of (often non-quantifiable) complexity. Design using these criteria also assumes students understand sociotechnical issues to which they have frequently had little to no prior exposure. Meanwhile, proponents of integration acknowledge the additional complexity and point out that it is a disservice to the next generation of engineers to define real design problems in artificially confined problem spaces. They argue that "design under constraint" is one of the definitions of engineering, and that learning sociotechnical issues within the context of design may be the context in which students are most receptive to learning and drawing from other relevant disciplines and knowledge sources. And the ability to do that is a central characteristic for effective problem solving by engineers. We hope this merited, spirited debate continues.

Acknowledgments

This work is part of a larger book project, *Engineering Justice: Transforming Engineering Education and Practice* (forthcoming from IEEE Press-Wiley), the focus of two of the authors (Jon Leydens and Juan Lucena). This book focuses on the theory, practice, and viability of rendering visible the relevant social justice dimensions within three engineering curricular areas: engineering sciences, engineering design, and humanities/social sciences courses for engineering students. Leydens and Lucena are quite grateful to the sage council, overall design expertise, and insightful understanding of design for social justice of co-author Dean Nieusma, without whom this paper would be much less refined, clear, and informative. Leydens and Lucena would also like to thank several years of Colorado School of Mines students who took the course Engineering and Social Justice; their input and perspicacity has helped shape both our definition and criteria for social justice in engineering. Nieusma would like to thank all participants in Rensselaer Polytechnic Institute's Programs in Design and Innovation, faculty and students alike. Together, the three authors would like to thank the three instructors of the design courses showcased in this paper for their time educating us about their courses and clarifying our first draft course descriptions. A big thank you also goes to CSM graduate student Santiago Robles for finding and assessing several sources used in this paper. Finally, we also appreciate the perceptiveness and encouragement of the two anonymous reviewers.

References

[1] Oosterlaken, I., [The capability approach, technology and design: Taking stock and looking ahead], in The capability approach, technology and design 5, Springer, Dordrecht, 3–26 (2012).

[2] Nichols, C., and Dong, A., [Re-conceptualizing design through the capability approach], in The capability approach, technology and design 5, Springer, Dordrecht, 189–201 (2012).

[3] Hirsch, P., Anderson, J., Colgate, J.E., Lake, J., Shwom, B., and Yarnoff, C., "Enriching freshman design through collaboration with professional designers," in Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition (2002).

[4] IDEO, "Human-centered design toolkit," IDEO Design Firm, Palo Alto, CA, 1–188 (2013).

[5] Nieusma, D., and Riley, D., "Designs on development: Engineering, globalization, and social justice," Eng. Stud. Engineering Studies 2(1), 29–59 (2010).

[6] Polak, P., [Out of poverty: what works when traditional approaches fail], Berrett-Koehler, San Francisco, Calif. (2008).

[7] Barry, B., [Why social justice matters], Polity, Cambridge, UK; Malden, MA (2005).

[8] Capeheart, L., and Milovanovic, D., [Social justice : theories, issues, and movements], Rutgers University Press, New Brunswick, N.J. (2007).

[9] Nussbaum, M.C., [Women and Human Development: The Capabilities Approach], Cambridge University Press (2001).

[10] Nussbaum, M., "Human Rights and Human Capabilities," Harvard Human Rights Journal 20, 21–24 (2007).

[11] Downey, G., and Lucena, J., "Are Globalization, Diversity, and Leadership Variations of the Same Problem? Moving Problem Definition to the Core," presented at Distinguished Lecture Presented at 2006 ASEE Annual Conference, June 2006, Chicago, IL, USA.

[12] Schneider, J., Lucena, J.C., and Leydens, J.A., "Engineering to help: The value of critique in engineering service," IEEE Technology and Society 28(4), 42–48 (2009).

[13] Lucena, J., [Engineers and Community: How Sustainable Engineering Depends on Engineers' Views of People], in Handbook of Sustainable Engineering, Springer-Verlag, New York, NY (2013).

[14] Downey, G.L., and Lucena, J.C., "When students resist: Ethnography of a senior design experience in engineering education," International Journal of Engineering Education 19(1), 168–176 (2003).

[15] Bardini, T., and Horvath, A.T., "The Social Construction of the Personal Computer User," The Journal of Communication 45(3), 40–66 (1995).

[16] Lindsay, C., [From the Shadows: Users as Designers, Producers, Marketers, Distributors and Technical Support], in How Users Matter: The Co-Construction of Users and Technology, MIT Press, Cambridge Mass. London, 29–50 (2003).

[17] Kouprie, M., and Visser, F.S., "A framework for empathy in design: stepping into and out of the user's life," Journal of Engineering Design 20(5), 437–448 (2009).

[18] Lucena, J.C., Schneider, J., and Leydens, J.A., [Engineering and sustainable community development], C. Baillie, Ed., Morgan and Claypool, San Rafael, CA (2010).

[19] Tatum, B.D., ["Why are all the Black kids sitting together in the cafeteria?": and other conversations about race], Basic Books, New York (1999).

[20] Johnson, A.G., [Privilege, power, and difference], McGraw-Hill, Boston, Mass. (2006).

[21] Pease, B., [Undoing privilege: unearned advantage in a divided world], Zed Books ; Distributed in the USA exclusively by Palgrave Macmillan, London; New York; New York (2010).

[22] Kimmel, M.S., and Ferber, A.L., [Privilege: a reader], Westview Press, Boulder, Colo. (2010).

[23] Schneider, J., and Munakata Marr, J., [Connecting the "forgotten": Transportation engineering, poverty, and social justice in Sun Valley, Colorado.], in Engineering education for social justice: Critical explorations and opportunities, J. C. Lucena, Ed., Springer, Dordrecht; New York, 153–177 (2013).

[24] Young, D., Mill, G., and Wall, R., "Feasibility of renewable energy storage using hydrogen in remote communities in Bhutan," International Journal of Hydrogen Energy 32(8), 997–1009 (2007).

[25] Baillie, C., Ed., "Waste for life - Who we are" (2013). http://wasteforlife.org/?page_id=2

[26] Baillie, C., Feinblatt, E., Thamae, T., and Berrington, E., [Needs and feasibility : a guide for engineers in community projects : the case of Waste for Life], C. Baillie, Ed., Morgan & Claypool Publishers, [San Rafael Calif.] (2010).

[27] Leydens, J.A., and Lucena, J.C., "Listening as a Missing Dimension in Engineering Education: Implications for Sustainable Community Development Efforts," IEEE Transactions on Professional Communication 52(4), 359–376 (2009).

[28] Ulrich, K.T., and Eppinger, S.D., [Product design and development], McGraw-Hill Irwin, New York (2012).

[29] Moriarty, G., "Engineering Design: Content and Context," Journal of Engineering Education 83(2), 135–140 (1994).
[30] MacKenzie, D.A., and Wajcman, J., [Introductory essay and general issues], in The social shaping of technology, Open University Press, Maidenhead, 3–27 (1999).
[31] Nieusma, D., "Alternative Design Scholarship: Working Toward Appropriate Design," Design Issues Design Issues 20(3), 13–24 (2004).
[32] Chambers, R., [Whose reality counts?: putting the first last], Intermediate Technology, London (1997).
[33] Nieusma, D., [Middle-out social change: Expert-led development interventions in Sri Lanka's energy sector], in Technoscience and environmental justice: expert cultures in a grassroots movement, G. Ottinger and B. R. Cohen, Eds., MIT Press, Cambridge, MA (2011).
[34] Winner, L., [Autonomous Technology: Technics-out-of-control as a Theme in Political Thought], MIT Press (1977).
[35] Winner, L., [The whale and the reactor: a search for limits in an age of high technology], University of Chicago Press, Chicago (1986).
[36] Noble, D., [America by design : science, technology, and the rise of corporate capitalism], 1st ed., Knopf, New York (1977).
[37] Nussbaum, M.C., [Frontiers of justice: disability, nationality, species membership], The Belknap Press : Harvard University Press, Cambridge, Mass. (2006).
[38] Nussbaum, M.C., [Creating capabilities: the human development approach], Belknap Press of Harvard University Press, Cambridge, Mass. (2011).
[39] Sen, A., [Development as freedom], Knopf, New York (1999).
[40] Sen, A., [The idea of justice], Belknap Press of Harvard University Press, Cambridge, Mass. (2009).
[41] [NSPE Code of Ethics for Engineers], National Society of Professional Engineers (2007).
[42] Oosterlaken, I., "Design for Development: A Capability Approach," Design Issues Design Issues 25(4), 91–102 (2009).
[43] Murphy, C., and Gardoni, P., [Design, risk, and capabilities], in The capability approach, technology and design 5, I. Oosterlaken and J. van den Hoven, Eds., Springer, Dordrecht, 189–201 (2012).
[44] Frediani, A.A., and Boano, C., [Processes for just products: The capability space of participatory design], in The capability approach, technology and design 5, I. Oosterlaken and J. van den Hoven, Eds., Springer, Dordrecht; New York, 203–221 (2012).
[45] Nussbaum, M.C., [Women and human development: the capabilities approach], Cambridge University Press, Cambridge; New York (2000).
[46] Lawson, B., [Design in mind.], Butterworth Architecture, Oxford (1994).
[47] Eglash, R., "PDI Studio," Course Description, Rensselaer Polytechnic Institute, http://homepages.rpi.edu/~eglash/eglash.dir/design.dir/syllabus2013.html (2014).
[48] Valencia, R.R., [The evolution of deficit thinking: educational thought and practice], Falmer Press, London; Washington, D.C. (1997).
[49] Graham, L., [The ghost of the executed engineer : technology and the fall of the Soviet Union], Harvard University Press, Cambridge, MA (1993).
[50] Eglash, R., "Distinguishing Generative Justice and Distributive Justice," presented at Engineering, Social Justice and Peace, 14 August 2013, Troy, NY, USA.
[51] Lima, M., and Oakes, W., [Service-Learning: Engineering In Your Community], Great Lakes Press, Wildwood, MO (2006).
[52] Werner, D., [Nothing about Us Without Us: Developing Innovative Technologies For, By, and with Disabled Persons], HealthWrights (1998).
[53] Herkert, J., "Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering," Science and Engineering Ethics 11(3), 373–385 (2005).
[54] Oosterlaken, I., and van den Hoven, J., [The capability approach, technology and design], Springer, Dordrecht; New York (2012).