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Juan Lucena *Editor*

Engineering Education for Social Justice

Critical Explorations and Opportunities

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Engineering Education for Social Justice

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Editor

Engineering Education for Social Justice

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Springer

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Part I
Introduction to Engineering Education and Engineering for Social Justice (ESJ)

Chapter 1
Introduction

Juan Lucena

Keywords Engineering education • Social justice • Education reform

This book contributes to and enhances recent efforts to meaningfully integrate social justice into engineering education. The book's two constituent elements—engineering and social justice—are very much about hope. Separately, the fields of engineering and social justice are about hope because those of us who enact, teach and/or benefit from them hope that their manifestations in the world, in the form of technologies or social policies, will bring some kind of social good and make the world a more compassionate, just place. Yet these two fields of practice and sources of hope have rarely come together, let alone become integrated. When they come together, it is often via clashing organizational, pedagogical, practical or technical manifestations, which often end in exacerbated social inequalities and injustices. So how might engineering educators, students and practitioners begin integrating these two fields of practice in the classroom, the lab, in fieldwork, in conferences, and other spaces of scholarly and pedagogical activity, in a way that results in more just technologies?

Intended for engineering educators, students, practitioners, engineering studies scholars, and many others interested in the interactions between engineering and social justice, this book project was born of a desire to provide examples that have attempted to integrate social justice and engineering education, in different places and taking different forms. This books follows on the footsteps of a growing literature on engineering and social justice (Baillie et al. 2010; Riley 2008; Baillie et al. 2012; Schneider 2010; Leydens et al. 2012) (See Chap. 2 by Nieusma in this volume for a detailed mapping of this body of work). Like some of those books, this one argues for taking seriously the relationship between engineering and social

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justice given the increasing role that technology and engineering play in our lives, sometimes exacerbating injustices and inequalities and other times contributing to a more fair redistribution of resources and opportunities. This book seeks to continue the growth of this new scholarly field.

Many political theorists and philosophers of technology have called to our attention the political dimensions of technology, especially how technologies might contribute to injustices and inequalities (e.g., Noble 1986; Cowan 1983; Wajcman 1991; Slaton 2010; Winner 1986). This scholarship continues to thrive within STS programs and inspire new dissertations, conference papers, course syllabi and book manuscripts. Yet those accounts rarely propose how the relationship between engineering and social justice might live inside the engineering curriculum and how it might be addressed by engineering faculty and students. This book begins to fill that void.

This book also brings together a diversity of perspectives, from junior and senior scholars affiliated in different ways with engineering education, holding different understandings and definitions of social justice, and often motivated by different struggles. It seeks to show that although interventions and curricular work in engineering and social justice are relatively new and risky, these can be done in a variety of ways by committed educator/activists of different ranks, occupying a variety of positions and locations within the curriculum, enjoying different levels of privilege, and living and working in different parts of the planet. I have also learned from research on barriers and opportunities that in order to include controversial topics in engineering education, such as humanitarian engineering (Leydens and Lucena 2009) or climate change (Lucena et al. 2011), one must pay close attention to institutional and political contexts since the success and long-term sustainability of curricular innovations and reforms depends heavily on how these stand in relationship to larger institutional goals and political practices (Spalter-Roth et al. 2007). Hence the contributions of this volume come from scholars studying, teaching, researching and serving in very different universities: small, large, private, public, in and outside the US. This diversity provides a wide spectrum of possibilities to scholars interested in experimenting with the integration of engineering and social justice in different kinds of institutions. This book seeks to provide a diversity of tone, content, strategies, experiences and struggles in its different chapters precisely to show how the integration of engineering and social justice looks like in different contexts.

1.1 Who Is This Book For?

Recently there has been much interest in connecting engineering practice and education with the needs and problems of the underserved and less privileged through programs in humanitarian engineering, community development, service learning, diversity, etc. This interest has resulted in well-intentioned attempts to help others, but it often overlooks any consideration of inequalities and injustices among those helping and those being helped. Most of these initiatives might be driven by a mindset that Donna M. Riley has labeled as “desire to help and the persistence to do it”

(Riley 2008) and can be grouped under the umbrella "Engineering to Help (ETH)" (Schneider et al. 2009). But as Riley reminds us, this mindset can blind engineers, educators and students to the impact of their well-intentioned work on social justice. This book is for them.

Since the 1980s there has been an explosion of diversity initiatives in science and engineering education to populate and diversify the "pipeline" (Lucena 2005). Yet most of these programs have not included analyses, critiques or strategies to deal with systemic inequalities along socio-economic classes or groups of students and practitioners from different sexual orientations. Most of these diversity programs remain focused on increasing numbers of women and underrepresented ethnic and racial minorities in engineering (which is a good and necessary goal) but continue to largely ignore injustices and inequalities in terms of social class and sexual orientation (McLoughlin 2012; Slaton 2010; Cech and Waidzunas 2011; Michaels 2007). This book is for the champions of diversity programs with the hope that they will begin incorporating concerns over social justice in their programmatic initiatives.

There are many engineering educators and students who, although seriously interested in social justice, believe that the place to deal with social justice should be outside of the technical curriculum, perhaps in humanities and social science courses (Johnston et al. 1988). There are others who believe that social justice does not belong in the curriculum at all, as it might be a distraction in an already over-crowded curriculum and as such it might better live in service and/or faith-based student organizations. This book is for them.

Among those who are interested in integrating engineering and social justice are students like those who take my Engineering and Social Justice (ESJ) class or those enrolled in the Design, Innovation and Society (DIS) dual degree program (with engineering) at Rensselaer Polytechnic Institute (See Chap. 2 by Nieusma in this volume for a detailed description of these curricular efforts). As I have shown in my class, students can learn to analyze the elements of the ideologies undergirding engineering, locate these historically, and then look for them in their sites of engineering education and practice. Once these elements and ideologies become visible, students begin to realize how taking them for granted act as blinders and impediments to their engagement of social justice; they soon wonder where else, and in which forms, we can have social justice integrated in engineering education. This book is for them.

During an ESJ faculty workshop in summer 2011, a privilege walk (see Chap. 9 by Leydens in this volume) revealed to participants key structural and cultural inequalities in engineering education. After 2 days of interactions and analyses of their privileges and mindsets, this group was eager to find out where and how social justice can find space in the engineering curriculum. As revealed by the course module developed by Jen Schneider and Junko Munakata-Marr (See Chap. 8 by Schneider and Munakata-Marr in this volume for a detailed description of the module), created after the workshop, there are engineering faculty not only eager to learn about the integration of engineering and social justice but willing to take it into the classroom. This book is for them.

There is also a growing community of engineering educators committed to bringing service learning into engineering, most of whom participate regularly on Engineering Faculty Engagement in Learning Through Service (EFELTS) workshops, and some who have already developed engineering projects and activities that incorporate forms of social justice and have transcended the blinding effects of the "desire to help" mindset (Tsang 2000; Lima 2006; Bielefeldt et al. 2010). This book is for them.

There are faculty who gravitate towards social justice by other means. For example, after lectures on my campus by some of the authors in this book, many engineering faculty and students have demonstrated a sincere interest in bringing social justice into engineering sciences and design (after Riley's lecture on social justice in thermodynamics), in making the inequalities experienced by LGBT students more visible to university faculty and administrators (after Cech's lectures on heteronormativity of engineering education), or in making social justice a more explicit dimension in renewable energy projects (after Sakellireaou's lecture on renewable energy). Clearly, these visits have left faculty and students energized and wondering how and where else to integrate social justice in engineering. It is possible that this interest is a localized phenomenon, a reflection of the presence of the ESJ lectures and ESJ course in my school. Yet I would argue that many of the faculty and students also attend these lectures because, like many of their peers elsewhere, they are hungry and interested in understanding how social justice can become more visible in their own curricular space. This book is for them.

Finally I am fully aware that there are also engineering faculty and students with apathy towards social justice. Many engineers believe that engineering should not have anything to do with social justice because of their commitment to an ideology of depoliticization of engineering that leads them to draw a boundary around the technical content and leave the non-technical (i.e., the social, the messy, the political, etc.) outside of engineering. This ideology was recently expressed in a *Machine Design* editorial entitled, "Why engineers shouldn't worry about social justice" (Teschler 2010) or in a recurring act of resistance by one of my students who stated, "I do not need to learn about social justice. That's what codes of ethics are for." Donna M. Riley might argue that this attitude reflects the influence of engineering mindsets (Riley 2008) and Erin A. Cech (See Chap. 4 by Cech in this volume) might see this apathy as a reflection of their commitment to the ideologies of engineering. Unfortunately, still many engineers believe that meritocracy in engineering works well, that inequalities are just outcomes of a fair system, and/or that social justice due to its social nature does not belong in the technical realm of engineering. This book is also for them.

1.2 Motivations for Putting This Book Together

During a NSF-sponsored workshop on Social Justice, Sustainable Community Development and Engineering at the National Academy of Engineering (NAE) in October 2008, a clear and vivid tension between the engineering profession and social justice came to life (Advisory Group for the Center for Engineering, Ethics, and Society; National Academy of Engineering 2010). Although NAE fully endorsed the workshop, title, and line-up of speakers, some influential engineers occupying key roles in engineering organizations, such as the US Army Corps of Engineers and National Society of Professional Engineers, strongly resisted proposals for the profession to embrace social justice. Clearly, few felt threatened by some definitions of social justice that made reference to redistribution of resources, opportunities and wealth and thus went as far as to equate social justice with socialism and labeled it as un-American. As Rachelle Hollander, lead organizer of the conference, succinctly puts it "It turned out that the question of engineering and social justice was a hotly contested topic at the meeting, while humanitarianism and engineering or engineering and social responsibility was not" (Hollander 2010). Some engineers participating in that workshop did not think social justice was an appropriate issue for engineering practice or for consideration in their societies; others disagreed. This was an interesting yet problematic dismissal of the possibility that engineering could actually contribute to a more fair and just distribution of resources. Why the anger, quick dismissal and closing of possibilities? Confused, I did not know at the time.

Leaving the NAE building in disbelief and walking around the Washington Mall to reflect on this experience, three of us with chapters in this volume (Leydens, Lucena, Schneider) came across the Franklin Delano Roosevelt (FDR) Memorial and its explicit references to social justice chiseled in rock, especially FDR's powerful quote that reads, "In these days of difficulty, *we Americans everywhere must and shall choose the path of social justice*, the path of faith, the path of hope and the path of love toward our fellow men." (emphasis added). The quote came from FDR's campaign address in Detroit, Michigan, October 2, 1932. The very next day the three of us agreed to begin writing a grant proposal that would allow us to explore, historically, conceptually and pedagogically, the incommensurability between engineering and social justice that we had experienced. Was it rooted in history? Was it a reflection of the ideologies of engineering? Or of the values of organizations where engineers work, teach, and learn? We wanted to know. In 2010 we received an NSF grant, began our research, course development, involvement in a network of engineering educators committed to social justice called Engineering, Social Justice and Peace (ESJP) (See Chap. 2 by Nieusma in this volume for a history of ESJP), and scholarly activism through faculty workshops with engineering educators, conference papers and classroom interventions. Along the way, we found people committed to social justice, in and out the ESJP network, many with more experience and courage than we had, facing different challenges and having travelled different trajectories. This book attempts to collect some of those experiences and give voice and visibility to courageous and dedicated scholars and colleagues that before us had begun the difficult and risky task of teaching about social justice in the engineering classroom.

After 2 years of teaching ESJ, I have come to realize how complex the task of bringing social justice into engineering really is. As a tenured male heterosexual Latino middle-class professor, holding two university degrees in engineering and two in science and technology studies (STS) from top research universities, I am fully aware of how these privileges allow me to open space to teach this course without raising too many questions. I have credibility in front of both engineering and social science colleagues, job security (tenure) that allows me to teach controversial topics, and rarely face discriminatory practices that unfortunately my homosexual and female colleagues encounter often in the culture of engineering education. From this position of privilege, I became intrigued about how others located at different pedagogical and institutional sites, and with more or fewer privileges than I have, conceptualize and propose the integration of engineering and social justice. I wanted us to learn from each other's experiences and struggles, establish a dialogue among ourselves and engage with a larger audience of engineering teachers, practitioners and students. This book hopes to further this dialogue and shared learning.

1.3 Historic Convergence of Circumstances

As we begin this dialogue and engagement, key questions still remain. Why might there be an increasing interest among engineering faculty and students for social justice? Might this be an intrinsic interest rooted in deep personal experiences? Perhaps. But could there also be a convergence of institutional factors and historical circumstances that lead more and more faculty and students to be interested in social justice? Trying to answer these questions clearly opens an opportunity for empirical research by engineering studies scholars. But let me propose a hypothesis here: In spite of individual personal interest for social justice, there is a convergence of two historical circumstances that is creating institutional opportunities to open spaces for an increasing number of engineers to teach and learn about the integration of engineering and social justice inside engineering schools. What might these circumstances be?

1.3.1 Calls for Change

As historians of engineering have described elsewhere, the history of engineering education is marked with repeated calls for change. Some of these calls are perennial (Reynolds and Seely 1993) while others have been adaptations to specific political and economic challenges facing the American nation at different times (Lucena 2005). Recently, with the US facing stiff competition in technological innovation and in the production of engineering graduates from countries like China and India, there are new calls to make engineering education more socially relevant as a way to increase the recruitment and retention of particular populations. Particularly, women and underrepresented groups find traditional engineering void of social relevance and want it to be "in touch with the world" as a precondition to stay in engineering (Brainard 2007; Buckley et al. 2004) As the NAE puts it, "curricular approaches that engage students in team exercises, in team design courses, and as noted above, in courses that connect engineering design and solutions to real-world problems so that the social relevance of engineering is apparent appear to be successful in retaining students" (National Academy of Engineering 2004, 54). These calls for the social relevance of engineering have materialized in programs that connect engineering curriculum with service learning, community development, humanitarian engineering, sustainability, and is perhaps most visible by the explosion of Engineers Without Borders (EWB) chapters in US engineering schools. There are now close to 300 EWB chapters in the US. And, as described above, some of the stakeholders behind these programs are yearning for an understanding of how their initiatives connect with social justice, how to bring social justice into their courses, and, in the process, how to recruit and retain more students.

1.3.2 An (In)Visible History

Engineering also has had a relatively invisible history of dealings with social justice (Wisnioski 2012). This history is fragmented, mostly unknown and yet shows promising signs indicating that the present time might be ripe for a wider and more systematic integration of social justice into engineering. As some of the authors in this volume rightly observe, major calls from the engineering profession, such as the publication of the Engineer of 2020 report, the issuing of the NAE Grand Challenges, and the formation of Engineering for Change (E4C), present both challenges and opportunities to an open dialogue about the relationship between engineering and social justice. As Nieusma describes in this volume, this dialogue has already begun in places like the NAE conference on Engineering, Sustainability and Social Justice, the sessions on social justice at ASEE Annual Conference (especially the one on the ethics of NAE's Grand Challenges in 2011), and even in the technical programs of conferences by engineering societies like ASME and IEEE. For reasons described above, this dialogue has begun to permeate engineering schools in the form of Engineering to Help, some of which are beginning to address important questions about inequalities and discriminations previously invisible to many, as the team-taught module by Schneider and Munakata-Marr exemplifies. Also, an increasing number of students are bringing these interests to the forefront, wanting to connect their engineering education and training with social problems related to the maldistribution of rights, resources and opportunities. In short, the total invisibility of social justice in engineering seems to be a thing of the past.

1.4 Defining Social Justice

As with any new scholarly and activist endeavor that appropriates a difficult term, those of us committed to integrating engineering and social justice face the challenge of defining social justice. Many scholars of social justice remind us that social justice does not have an easy and straightforward definition (Riley 2008; Ayers et al. 1998; Brooks 2008). Its definition depends on our cultural, political or philosophical position in the world (Marxist, feminist, deep ecology, faith based, Rawlsian, etc.) and on our commitment to social groups experiencing inequalities that we want to correct (working poor, women, LGBT, disabled, etc.). In spite of these ambiguities and not pretending to speak for all the authors in this volume, I begin my ESJ course by providing engineering students with a working definition that relies on key elements drawn from philosopher Brian Barry (2005) on which they can focus their engineering practices and designs:

> Social justice practices, including those by engineers, should attempt to an equal distribution of rights, opportunities and resources in order to enhance human capabilities and reduce the risk and harms among the citizens of a society.[1]

By recognizing that "attempting" does not necessarily mean "realizing", I try to persuade those students who, like some of the engineers at the NAE conference, might be initially uncomfortable with or resistant to redistributing resources. Then to fully understand the constituent elements of this definition, and the contributions that engineering might make on these, my students study the following questions:

- where do we look for people's **rights** (e.g., state and country political constitutions, UN declaration of human rights) and how might engineering, its practices and products enhance or hinder specific human rights?
- how do **opportunities and resources** differ among groups of different races, genders, physical abilities, socio-economic classes, sexual orientations, etc. and how might engineering, and its practices and products, contribute or diminish specific opportunities and resources?
- how can engineering's contributions to rights, opportunities and resources be, after all, about enhancing **human capabilities** and reducing **risks and harms**?

In short, this definition challenges engineers to focus on specific means (engineering) to contribute to primary ends (rights, opportunities, resources) that will eventually lead to higher goals (enhancing capabilities, reducing risks/harms). Yet I do not assume that this definition, or others that I have tried, might be the most appropriate to engage all engineers in their quest for social justice. Hence the chapters in this volume aim at providing a diversity of definitions, examples and forms of engagement.

1.5 How This Book Approaches ESJ: Autobiographical, Historical, Philosophical, Pedagogical, Practical and Beyond

My ESJ class begins with a privilege walk (see Peggy McIntosh's chap in Rothenberg 2003) and a series of autobiographical exercises to expose students to the concept of privilege (earned and unearned), how these accumulate (or are diminished) from

[1] I am in debt to philosopher Martha Nussbaum for reminding us that social justice practices, like other forms of human and social development, should be, after all, about the development of human capabilities (Nussbaum 2011).

womb to profession, how these are dependent on rights, opportunities and resources, and how these might eventually lead to enhancement of human capabilities. Then we explore the engineering mindsets as outlined by Riley (2008), study where and how these are manifested in engineering, and where they come from in the philosophical, historical and social roots of engineering. Next we explore how privileges and mindsets enhance and/or hinder engineers' abilities to engage social justice issues, and how to resist and/or subvert the negative effect of mindsets and privileges in order to do social justice work. Students research and present on historical and contemporary examples of engineers engaged in social justice work and write a final analysis of how this journey, through the intersections between engineering and social justice, challenge them as persons, future engineering professionals and influence them on the kinds of technologies that they want to design, build and operate.

Yet my course is just an introductory exploration to the intersection between engineering and social justice. There are many aspects, approaches, historical events and exemplars that I cannot cover due to limitations of time, my own expertise and institutional context. I am fully aware that my course is an incomplete micro-cosmos of the larger universe of engineering and social justice. Wanting to explore this larger universe is one of the motivations for this book. So what sort of approaches—conceptual, pedagogical, autobiographical, activist, etc.—can we expect from this book?

Dean Nieusma's chapter provides a *historical and conceptual mapping* of ESJP, the first network of engineering educators, practitioners and students who organized themselves explicitly "to work toward engineering practices that enhance gender, racial, class, and cultural equity and are democratic, non-oppressive, and non-violent." Furthermore, Nieusma maps different educational and professional reform strategies that ESJP members have used in order to bring social justice into the engineering curriculum.

Donna M. Riley's chapter provides both an *autobiographical and activist approach* to her experiences of discrimination in engineering and her struggles to bring social justice into the curriculum. Through her journey, Riley reveals practices and systems of inequality and discrimination in engineering education, the importance of crossing disciplinary divides into critical perspectives on education (mainly Paolo Freire and bell hooks), and the courage of teaching engineering students about power by asking important questions: Who benefits from the problems that we solve? What gets in? What stays out? Riley is located where some of us would like to be: inside the engineering science curriculum (thermodynamics), trying to connect apparently abstract and apolitical concepts with questions about power and inequality.

Through *empirical research on students' experiences* with discrimination and inequality in engineering education, Erin A. Cech's chapter provide a very useful refinement two key concepts that most of us take for granted in engineering: the split between the technical *vs.* non-technical and meritocracy. Then she shows how these work against engineers' ability to engage in social justice, and with these concepts complement the map that Riley began when mapping the engineering mindsets.

An computer scientist/engineer and doctoral candidate in engineering education, Marisol Mercado Santiago attempts to build a *philosophical bridge between engineering and Buddhism*. Although there are dispersed elements in engineering education that resemble Buddhist principles and values, there is no framework yet to bring a closer integration between Buddhism and engineering, particularly one that serves the interests of social justice. Marisol's chapter attempts to "motivate engineering educators, who are interested in Buddhism and social justice, to connect their engineering knowledge with Buddhist studies in socially just engineering education."

Also a doctoral candidate in a program that combines electrical engineering and engineering education and an engineer himself, Ryan C. Campbell provides a *theoretical outline of caring in engineering*. Although care and caring are common words in the vernacular of some engineering for service programs, Campbell reconceptualizes caring, which he defines as "an active compassion, empathy, and concern for the well-being of other living things," as a key and necessary element for engineering education to truly embrace social and ecological justice.

In their chapter, Caroline Baillie and Rita Armstrong present empirical research that maps how *knowledge boundaries and threshold concepts* influence engineering students' understanding of social justice. Baillie's engineering and engineering education backgrounds come together with Rita Armstrong's anthropological work and activism in a process of negotiation to show their engineering students, many of whom will be hired by extractive industries in Western Australia, a place where aboriginal peoples are experiencing undue pressures on their livelihoods, the value of crossing disciplinary boundaries and identifying threshold concepts in creating a pathway towards social justice.

Jen Schneider and Junko Munakata-Marr describe in their chapter how they guided their students in a sustainable engineering design class to analyze the social justice dimensions of a public transportation project in a neighborhood with people living below the poverty line. Like Baillie's and Armstrong's, this teaching partnership serves as an example of the importance of *interdisciplinary collaborations in creating opportunities for social justice in the engineering classroom*, and shows how we can create a community service activity close to home where the social justice dimensions are more visible, relevant and connected to students.

Jon Leydens' chapter identifies sources of faculty resistance to integrating social justice. Leydens' work challenges us to respect and pay close attention to these forms of resistance, and explores the contributions of Social Justice Across the Curriculum (SJAC) initiatives in *developing guidelines for faculty to facilitate the overall integration of social justice in engineering*. Although initially designed for humanities and social science curricula, the proposed guidelines have multiple implications for addressing faculty resistance across the entire engineering curriculum.

Wanting to contribute to our understanding of how the *politics of technological systems relate to social justice*, Andres Valderrama's chapter presents empirical research on how real engineered systems, in the form of public transportation systems in Colombia, hide biases against marginalized groups. Valderrama goes after a taken-for-granted assumption (*i.e.*, that models and assumptions made in the design of engineered systems are value neutral) to show how engineers, and their political patrons, while often articulate visions of social justice, might be blind to hidden unjust assumptions in their modeling that eventually lead to injustices and inequalities.

In his chapter, Richard Arias explores the *historical emergence of NGOs as sites for work and activism of Colombian engineers committed to social justice* and analyzes the multiple definitions that engineers give of social justice while working in NGOs. This is a topic of great interest to many engineering students as they often wonder what would it be like to work as an engineer for an NGO, to engineering studies scholars as most studies of engineers in the workplace have focused on corporate and government environments, and to engineering educators because, as Arias writes, "universities and engineering schools develop curricula to construct engineers for the private sector and the public sector, but not for the nonprofit sector. Since the nonprofit sector follows a different logic, engineering schools are normally at odds with this kind of engineering."

Finally, in his chapter, Nicholas Sakellariou explores the social justice dimensions in one of the most exciting areas of engineering innovation: renewable energy. He challenges us to explore the unquestioned assumptions about the social good of these technologies by *questioning the social justice dimensions in the production and use of these forms of energy*. He then provides a framework for engineers to engage communities in decision-making processes (procedural justice) in a way that will eventually lead to social justice.

In addition to these individual chapters, the organization of this book in parts is also aimed at making the following contributions to engineering education and practice relevant and useful to those who might have specific concerns or needs:

- **Part II. Where Have We Been**? **Where Can We Go**? A map of where ESJ has been (Nieusma) and how some of us have experienced injustices and what have we done about it (Riley).
- **Part III. Conceptual Contributions to ESJ**. New philosophical (Campbell, Santiago) and sociological (Cech) concepts that can enhance our understanding of how to integrate engineering and social justice.
- **Part IV. What Gets in the Way and How Can ESJ Live in the Engineering Classroom**? Specific examples of threshold concepts that get in the way and need to be overcome to enhance students understanding of social justice (Baillie and Armstrong), how social justice can be integrated in an engineering course (Schneider and Munakata-Marr) and guidelines to facilitate the integration of social justice education within engineering education (Leydens)
- **Part V. What Thinking about Social Justice in Engineering Practice Can Offer to Engineering Education**. Empirical evidence of how the integration and conflicts

between engineering and social justice looks like in practice in transportation systems (Valderrama), NGOs (Arias), and renewable energy projects (Sakellariou).

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Part II
Where Have We Been? Where Can We Go?

Chapter 2
Engineering, Social Justice, and Peace: Strategies for Educational and Professional Reform

Dean Nieusma

Abstract This chapter surveys a range of educational and professional reform efforts in engineering carried out by the Engineering, Social Justice, and Peace network and its members. These efforts are categorized in a way that highlights the diversity of the approaches taken as well as their interconnections. Beyond documenting and categorizing a range of contemporary initiatives in engineering and social justice, the chapter argues that, to be most effective, ESJP members attempt to integrate their particular values orientations and commitments with systematic attention to a wide range of organizational and conceptual problems that inhibit engineering for social justice and peace.

Keywords Engineering, Social justice, and Peace network • Engineering educational reform • Engineering professional reform • Engineering conceptual reform • Social-technical integration

2.1 Introduction

Social justice is a big idea, with multiple meanings—some of which exist in tension and others of which are simply contradictory. From certain perspectives, the very concept of *social* justice is fraught. Spirited debate over the appropriateness of the

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This chapter refines and considerably extends a paper presented at the 2011 Annual Conference of the American Society for Engineering Education in Vancouver, Canada (Nieusma 2011a) and a related presentation at the 2011 annual meeting of Engineering, Social Justice, and Peace in Bogotá, Colombia (Nieusma 2011b).

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terminology was a highlight of the US National Academy of Engineering (NAE) workshop, "Engineering, Social Justice, and Sustainable Community Development," held in October of 2008 at the NAE headquarters in Washington, DC. At this event, a small but vocal minority expressed dismay over use of the term "social justice" by the esteemed NAE, suggesting it represented a socialist political agenda that members of the NAE should appropriately reject, not embrace.

Despite such resistance, many engineers and engineering commentators take the desirability of social justice—and the appropriateness of the engineering profession to work systematically toward it—as being self-evident. Directing engineering initiatives at individuals and social groups with particular vulnerabilities—including the global poor, local community groups, disabled persons, and many others—is on the rise, with an explosion in the number of organizations or affiliates engaging in on-the-ground, service-oriented engineering work over the past decade (Nieusma and Riley 2010).

Numerous approaches to social justice are represented in contemporary engineering practice and education. Many of these approaches use the terminology of social justice explicitly.[1] Others are motivated by concerns about social injustices, but avoid applying the label of "social justice" to their efforts for strategic or other reasons. Much of the work of Engineers Without Borders–USA and Engineers for a Sustainable World fits this description. For instance, Engineers Without Borders uses the language of "social responsibility" in describing its values, but avoids explicit reference to "social justice" throughout its 2010 Strategic Plan (EWB-USA 2010). Similarly, Engineers for a Sustainable World uses the term "social sustainability" in describing its vision and goals (ESW 2012).

Still others carry out work with immediate implications for advancing social justice without being motivated directly by that particular goal. For instance, the widely referenced 2008 NAE report, *Grand Challenges for Engineering*, promotes the application of engineering ingenuity to contemporary social problems in a way that is broadly consistent with a social-justice agenda. Despite non-trivial shortcomings,[2] this report represents a larger trend within engineering toward explicit efforts to advance "the social good."

This chapter describes the efforts of a network of engineering educators, practitioners, and students who take a further step in promoting social justice. This group, collaborating under the banner, Engineering, Social Justice, and Peace (ESJP), promotes a vision of social justice that goes beyond helping vulnerable populations to identifying and confronting the *systems and structures that lead to*

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[1] Donna M. Riley's *Engineering and Social Justice* (2008) is noteworthy for its attention to the intersection of engineering and social justice as its primary analytic theme. Other work by members of the Engineering, Social Justice, and Peace network—the topic of this chapter—obviously fits here as well. See, e.g., Caroline Baillie and George Catalano's *Engineering and Society: Working Toward Social Justice, Parts I, II, and III* (all 2009a, b, c).

[2] A session at the 2011 Annual Conference of the American Society for Engineering Education was dedicated to critically analyzing the approaches and underlying assumptions represented in the NAE's (2008) *Grand Challenges of Engineering* report (see Catalano 2011; Herkert 2011; Nieusma and Tang 2011; Riley 2011; Slaton 2011).

injustices. As a network of affiliated participants, ESJP's mission (and name) lies at the exact intersection of engineering and social justice. ESJP "works toward engineering practices that enhance gender, racial, class, and cultural equity and are democratic, non-oppressive, and non-violent. We seek to better understand the relationships between engineering practices and the contexts that shape those practices, with the purpose of promoting local-level community empowerment through engineering problem solving, broadly conceived" (ESJP 2012).

ESJP carries out a range of direct action, community-based, scholarly, and organization-building activities, and its members individually and in collaboration have initiated numerous efforts aimed at making social justice and peace more central to engineering as a field of practice. This chapter surveys some of these activities, focusing specifically on *educational and professional initiatives* by summarizing and categorizing them to show how they work at various levels of reform. ESJP members also carry out a considerable amount of situated community development work and direct-action and scholarly activism, including issues-based initiatives around themes like: peace advocacy; animal rights; disability support; racial, gender, and economic justice; LGBT rights; and indigenous rights. While an important part of ESJP's overall approach, a review of these activities is left to future research.

Beyond documenting a range of contemporary initiatives in engineering and social justice, the chapter argues that, to be most effective, ESJP members integrate their particular values orientations and commitments with systematic attention to a wide range of organizational and conceptual problems that inhibit engineering for social justice and peace. Hence, the chapter treats ESJP not merely as a network of like-minded individuals collaborating to promote a shared vision of social justice within engineering—although it is that. More important, however, is ESJP's range of strategies that target diverse audiences at multiple scales of intervention to connect social justice commitments with the institutional changes needed for materializing those commitments.

2.2 Background: A Short History of ESJP

While the precise origin of any complex initiative is difficult to specify exactly, the first of what has become an annual meeting of the ESJP network was organized by Caroline Baillie in 2004: The "Engineering for Social Justice" conference was held in November at Queen's University in Kingston, Ontario. That event was attended by over 20 participants, including George Catalano. Catalano collaborated with Baillie to host the second meeting in April, 2006 at Binghamton University in Binghamton, New York, at which point the event was renamed to "Engineering, Social Justice, and Peace" and organized as a workshop.

This second meeting had 31 participants, four of whom (including the author) would go on to become regular collaborators. ESJP's first publication, the 'zine, *Reconstruct*, was issued in the summer after this meeting for distribution at the American Society for Engineering Education's 2006 annual conference. The meeting also saw the birth of "ESJP" as a signifier pointing to something meaningful in the world—at this time, mainly an event (i.e., the henceforth annual meeting) but also a small community of scholars and activists collaborating around the theme of engineering and social justice.

The third meeting was hosted again by Catalano and held at a retreat setting just outside Binghamton in April, 2007. This meeting had 24 attendees, including two more who would go on to become regular participants, and ended with a commitment to rotate responsibility for hosting future meetings. As a result of this commitment, the fourth meeting was organized—this time in a conference format—by Donna M. Riley and held in April, 2008 at Smith College in Northampton, Massachusetts. With 38 attendees turning out and a growing group of regular participants, this meeting saw the formalization of the ESJP network. Regular participants formed a coordinating committee and established a menu of ESJP-sponsored activities.

The following three annual meetings served to further institutionalize and grow the ESJP network. The June, 2009 meeting, organized and hosted by Chris Byrne in Whidbey Island, Washington (outside Seattle), included significant participation by practicing engineers employed in a range of local engineering firms. At this retreat-style meeting, participants strategized and categorized the full range of activities ESJP would pursue, including organizational development (e.g., commitments, identity, website, outreach), research (e.g., bibliography, conference venues, a journal), and activist initiatives (community engagement, 'zine).

In 2010, the ESJP meeting first moved outside of North America. Held at the Royal Society for the Encouragement of Arts, Manufactures and Commerce (the RSA) in London, and organized again by Caroline Baillie, this meeting attracted a range of new participants representing international development perspectives, including delegations from Engineers Without Borders Australia and Ingenieros sin Fronteras Colombia (ISFC, Engineers Without Borders Colombia). This meeting put the relationship between social justice and development squarely on the table.

The 2011 meeting saw ESJP's first move to the global South. Held in Bogotá, Colombia, and organized by Juan Lucena, Maria C. Ramírez, and Andrés Valderrama, this meeting was notable for including a high level of interaction with peoples suffering injustices, particularly Bogatá's urban poor. This meeting was held in conjunction with an ISFC seminar and entailed considerable reflection on cross-national differences in understandings of social justice.

Currently, "ESJP" points both to a network of engineering reformers (see, esjp.org) and to some of its sponsored activities, most notably the annual meeting. Activities organized in the name of ESJP are overseen by a coordinating committee (numbering eight members as of March 2012), including the authors of this and other chapters in this volume. Several additional people participate regularly in the group's decision making, and a much larger number contributes to specific ESJP activities or publications. In all, perhaps approximately 500 people have participated directly in an event organized by ESJP, not including the numerous talks, panels, and workshops organized around ESJP's activities but presented at independently-sponsored events (e.g., engineering education conferences, community workshops, etc.).

2.3 Methods and Scope

As part of the organizational strategy discussions that took place at the 2009 ESJP meeting, participants agreed to initiate a research project on "approaches to engineering and social justice," which I volunteered to spearhead. The idea was to initiate a participatory action research project that surveyed members' approaches to social justice in engineering in order to delineate and share the diversity of approaches taken. This chapter draws on and contributes to that original project, yet the chapter also extends beyond that project by looking reflexively at what ESJP has achieved as a reform initiative in its own right—above and beyond the approaches taken by any of the participants individually or in small groups.

The approaches to social justice-based engineering reform highlighted in this chapter were identified by surveying initiatives carried out by members of ESJP, situated as they are in diverse and geographically dispersed institutions of higher education. For the purposes of this analysis, the approaches surveyed are categorized both around the context of intervention and around the underlying intervention strategy. The empirical material driving the analysis comes from direct participation in a variety of ESJP initiatives, communication and association with ESJP members, and reviews of published literature and Internet material about their activities.

The material reviewed has North American/global North empirical and cultural biases, due to the location of the work and research contexts of most ESJP members, including those of the author. The material is also limited to initiatives spearheaded by regular ESJP participants and does not extend to include the inevitably wide-ranging, related work by reformers in overlapping circles.

2.4 Educational Reform Strategies

The first category of ESJP reform strategies to be reviewed revolves around engineering education, including a range of initiatives in pedagogy, curriculum design, and institutional restructuring. Here, *pedagogy* refers to strategies and methods for teaching engineering students, usually but not always pursued in (and confined to) the context of the classroom. *Curriculum design* entails working at the level of educational program requirements that have impacts beyond individual classes and their instructors. And *institutional restructuring* points to changes to the constraints under which educational programs operate, including institution-wide requirements maintained by specific educational institutions, voluntary or mandatory accreditation requirements, and so forth. These types of educational reform initiatives turn the engineering learning environment into an opportunity to understand, to identify, and then to confront injustices arising from engineering educational practices and structures.

2.4.1 Pedagogical Initiatives

This section reviews different approaches to reforming what and how engineering students are taught within the context of specific courses. As university instructors, members of ESJP regularly bring their reform strategies and social-justice expertise to their teaching. Five separate cases are used to illustrate the different approaches, which are organized in a spectrum of experimentation spanning from course content to the learning process.

2.4.1.1 Liberal-Education Courses

Perhaps the most straightforward strategy for increasing attention to social justice in engineering education is to offer courses with social justice content that fit into existing program requirements. In many educational settings, including in the US context, the most evident place to introduce such content is the general/liberal-education component present in most engineering curricula, historically conveyed as humanities and social sciences (H&SS) requirements.

Most US engineering programs include H&SS requirements, sometimes with modest breadth and depth components. Since these programs typically take an *a la carte* approach to meeting H&SS requirements, students usually have considerable flexibility in selecting general education courses even when their science and technical engineering courses are rigidly specified. For the ESJP participants who are situated in liberal arts units at their respective universities, H&SS requirement combined with *a la carte* course selection provides an opportunity to create courses dedicated to social justice themes, including as they intersect with engineering.

In his 2010 dissertation, Jens Kabo analyses three different "lenses" for social justice as manifest in undergraduate liberal arts-content courses taught by ESJP members. In 2008 and 2009, Kabo's thesis advisor, Caroline Baillie, taught a Queen's University course entitled "Engineering and Social Justice," which brought together engineering and social sciences students to ask: "What is engineered? Who is it engineered for? What happens inside engineering organisations? Is it equitable?" (Kabo 2010, 123). The course entailed two major components: (1) deconstructing dominant rationalities around neo-liberalism and technological progress and (2) identifying alternative engineering practices that are "non-oppressive, non-capitalist, and ecologically sustainable" (124).

The second course Kabo studied was Donna M. Riley's "Science, Technology, and Ethics," which was offered in 2008 as an elective to students in Smith College's Picker Engineering Program. In Riley's words, the course took a "macroethics" approach (see, e.g., Herkert 2005), tackling the "larger question of social decision making" rather than looking more narrowly at professional ethics (cited in Kabo 2010, 179). This course covered themes such as: objectivity and its critique, science and technology funding, consumerism, social inequality, feminist theory, and dissent. (The course also employed a "liberative pedagogy" approach, see below; also, see Chap. 3 by Riley in this volume for an in-depth description of her trajectory before, during, and after this course.)

The third course Kabo studied was my own "Sustainable Design Politics and Culture" course, an upper-level H&SS elective offered in 2008 at Rensselaer Polytechnic Institute. This Science and Technology Studies (STS) course targeted engineering and design students by highlighting the political and cultural underpinnings of sustainable design initiatives. The course was intended to "provide students: (1) the conceptual tools to understand social power, (2) the space to have discussions where that becomes a relevant method to understanding the world, and (3) topics or content that's not about social justice [per se], but has the potential to become a conversation about social justice by its nature…: [Y]ou can't go very far in talking about sustainability before you start to talk about who has what and why" (cited in Kabo 2010, 149–150).

Each of the three courses Kabo studied took a different approach to integrating social justice content into engineering H&SS electives: Baillie addressed the topic directly and explicitly; Riley introduced the topic using the language of ethics; and my course introduced it through the concept of sustainability. Beyond Kabo's study, Juan Lucena developed an H&SS elective course entitled, "Engineering and Social Justice," in 2010. Lucena takes a direct and explicit approach to social justice, which integrates STS theoretical approaches with content on diverse dimensions of social justice involving engineering practice and organizations, including: the objectivity myth, technical narrowness, desire to help, authority structures, and corporate and military influence.

2.4.1.2 Technical Course Modules

A related approach to making social justice content more readily available to engineering students is to introduce it in technical/core engineering courses. This approach was taken by George Catalano at Binghamton University in Binghamton, New York. Catalano spearheaded an effort to create a series of course modules on social justice themes that could be easily integrated into traditional technical engineering courses (Catalano et al. 2008a). This approach also responds to curricular over-crowding: "Realities of the present engineering curricula prevent the possibility of additional courses" (Catalano et al. 2008b). But perhaps more importantly, by providing stand-alone modules, this approach enables engineering educators without expertise in social justice content areas to integrate such content into their courses. The independent module may inadvertently contribute to already extreme segregation of technical and social expertise among engineering faculty, but it also offers the possibility of a soft landing for technical faculty teaching social justice content for the first time.

Catalano's initiative was funded by Campus Compact, an organization dedicated to promoting community service in higher education; consequently, many of the modules emerge from particular community contexts and problems. Catalano brought together material from ESJP participants and others to produce wide-ranging modules of various levels of complexity, spanning numerical methods for analyzing poverty trends, thermodynamics applied to food energy analysis in the context of obesity and poverty, development of an index for measuring social justice, and the design of renewable energy systems for rural villages in poor countries. Several of the modules were created by Katy Haralampides, who is at the University of New Brunswick. Her modules include: New Orleans traffic flow analyses in the wake of Hurricane Katrina, class equity questions surrounding "payday loans," and a range of statistical analyses of global health disparities, environmental pollution, electronic waste flows, water quality assessment, and immigration. Across these modules, Catalano seeks to "nurture the development of both analytical skills and compassion in students and future engineers to effectively deal with the problems of peace, of poverty and of environmental degradation" (Catalano et al. 2008b, 5). (See Chap. 8 by Schneider and Munakata-Marr in this volume for another approach to using modules in a technical course.)

2.4.1.3 Critical Learning Thresholds

A very different approach to pedagogical reform—this one existing at the intersection of course content and learning process—is taken in the work of Jens Kabo (2010), who as mentioned above studied under Caroline Baillie at Queen's University in Kingston, Ontario. While the empirical material of Kabo's research included undergraduate courses thematically related to social justice and engineering, his theoretical contribution centers on "learning thresholds."[3] Kabo investigated the processes by which students confront, grapple with, and ideally pass through cognitive thresholds associated with particularly challenging concepts whose understanding is central to comprehension in the associated area of inquiry. (See Chap. 7 by Baillie and Armstrong in this volume for recent work in this area.)

Kabo analyzes engineering undergraduate students confronting thresholds relating to "social justice," and shows how they represent a spectrum of increasingly complex analytic positions:

- "Social justice as no understanding, misconceptions, or contradictions"
- "Social justice as fragmented understanding and/or isolated characteristics"

[3]This work draws on the emerging framework of threshold concepts originated by Erik Meyer and Ray Land (2003).

- “Social justice as helping and/or responsibility”
- “Social justice as changing society”
- “Social justice as a critical lens” (Kabo 2010, 259).

Kabo concludes from his investigation of students’ location on this spectrum: “if the educational aim is for students to develop an articulated understanding of social justice then an explicit focus on social justice is preferable over addressing social justice implicitly through focus on other topics” (Kabo 2010, 257). But Kabo’s thesis also identifies a range of successful pedagogical strategies for moving students through difficult thresholds, including discussion-centered teaching, reflection and self-criticism on the part of instructors, small class size, engaging real problems facing communities, continuous emphasis on the centrality of critical thinking, and instructor flexibility in responding the to particular conceptual challenges faced by students.

2.4.1.4 Experiential Learning

A fourth approach to pedagogy reform shifts from “learning about” social justice content to more active or experiential approaches to learning, including project or problem-based learning (PBL) models and community-engagement or service-learning models. Interest in all of these model types is exploding in engineering education circles currently,[4] with a correlate increase in consideration of contextual issues that connect engineering practice to questions of social justice. Many members of the ESJP community have experience with active-learning approaches, including some of Catalano’s course modules introduced above. However, the work of Andrés Felipe Valderrama Pineda and Maria C. Ramírez stands out.

As co-founders of Ingenieros sin Fronteras Colombia (ISFC, Engineers Without Borders Colombia), Valderrama and Ramírez promote a model of experiential learning that is both analytical and highly reflexive (Valderrama Pineda et al. 2012). Because ISFC is directed primarily by university engineering faculty members, the organization embeds students’ service work within larger research and development initiatives and provides considerable project oversight. While this structure may reduce opportunities for students to develop independent leadership capacities, it nevertheless facilitates students making connections among their service project work, their technical coursework, and contextual analysis demanded by experiential learning approaches.

Engineering students who participate in ISFC projects work on a range of clean-water technology projects, from clean water design challenges to installing water filtration technologies in local communities to international collaborations (with China and Italy) on community-based water solutions. Because contextual

[4] See for example the multi-institutional collaboration, “Engineering Learning through Service” (sites.tufts.edu/efeltsworkshops/) and the open-source *International Journal for Service Learning in Engineering*, first published in 2006 (library.queensu.ca/ojs/index.php/ijsle).

sensitivity is such an important part of ISFC's process, they "actively involve the community in the identification of problems and the design of viable solutions, and often involve several local and international institutions in an effort to approach these problems from multiple perspectives" (Valderrama Pineda et al. 2012). But more interesting, perhaps, is the tendency toward critical self-analysis: "We propose that only an honest and analytically grounded study of our own actions can contribute to refining our goals, our means and our projects in order to avoid the betrayal of our own intentions—namely, to avoid replicating a neo-colonial attitude" (Valderrama Pineda et al. 2012).

Another experiential-learning initiative is Waste For Life, a "loosely joined network of scientists, engineers, educators, architects, artists, designers, and cooperatives working together to develop poverty-reducing solutions to specific environmental problems."[5] With regular participation by Caroline Baillie, Eric Feinblatt, and others, Waste for Life connects engineering expertise to community problems and community resources for community benefit. The educational dimension of the organization's mission is explicit: "By bringing social and environmental norms into classrooms and linking them to interdisciplinary and collaborative experiences, which are necessary components of our work, WFL offers students alternative ways of practicing their skills and an alternate purpose for their professional goals."[6]

2.4.1.5 Liberative Pedagogies

A fifth pedagogical approach is conveyed through Donna M. Riley's work on "liberative pedagogies" (Riley 2003, 2012). Extending from the work of bell hooks, Paulo Freire, and others, liberative pedagogies seek to empower students as learners (and political actors) by legitimating their experiences and perspectives and giving them greater autonomy in the learning environment. By calling attention to and then challenging hierarchical power structures, in particular, including those in the classroom, the approach devolves authority to students to direct their individual and group learning:

> "At their core, liberative pedagogies are about developing sensitivity to power relations in the classroom. We cannot ever do away with power in the classroom; however, we can play with power relations and seek to transform those relations and learn more about freedom and resistance" (Riley and Claris 2009, 41).

Liberative pedagogies are a different type of active learning than problem-based or service-learning approaches. While both approaches attempt to move students from a position of passive receiver of information to active producer of knowledge, only liberative pedagogies interrogate the power relations that determine how learning is structured. "Whether traditional or learner-centered, pedagogies that

[5] See http://wasteforlife.org/?page_id=2, accessed 22 April 2012.

[6] See http://wasteforlife.org/?page_id=2, accessed 22 April 2012.

are not conscious of power relations teach engineers to conform to systems of power, and to operate within those systems in order to succeed" (Riley and Claris 2009, 38). With liberative pedagogies, students share responsibility for determining what the learning process should entail and how it is to unfold. The instructor's role also changes from one of providing information in a one-way communication process to facilitating the creation of a vibrant learning environment whose content is not predetermined but builds upon student dialogue, interaction, and inquiry.

Formalized educational settings, such as that of university-based engineering education, clearly provide constraints to the "devolution of authority" demanded by liberative pedagogies. Ultimately, students report to course instructors, and course instructors provide the final assessment of students' work (usually via the course grade/mark, point count, percentage, etc.). Nevertheless, by acknowledging these constraints and their structural dimensions—and by including critical reflection upon them as part of the educational moment—instructors can help students overcome their resistance to resistance itself. (See Chap. 3 by Riley in this volume.)

2.4.2 Curricular Initiatives

Another dimension of educational reform initiatives is curricular experimentation, which moves beyond the individual classroom to the larger structures that determine which content is to be required and in what proportions, how and when it is to be conveyed, and who decides according to what process. This section reviews two approaches to curricular reform connected to members of ESJP. These curricular reforms overlap with, but extend beyond, some of the pedagogical reforms described above. In some respect, these curricular reforms can be seen as projections of those pedagogical innovations into academic programming. The two curricular reform categories reviewed include: (1) better structuring of general education content and (2) better integrating social with technical content in engineering design.

Notably absent from this short list are efforts to systematically integrate social justice content *across* "core" engineering science courses in a given curriculum. While members of ESJP have paved new paths within individual core courses, what curricular experimentation there is exists at the margins of engineering curricula (i.e., the non-core courses: design, professional development, H&SS content). While there are certainly many reasons for this absence, not least of which is the marginal status of social justice content within engineering generally, highlighting the gap points to opportunities for future work in this domain.

2.4.2.1 Structuring General Education Content

As introduced above, the *a la carte* approach to general education (and specifically, here, H&SS) requirements in engineering programs produces several deleterious but predictable results. Engineering students with unstructured H&SS requirements can avoid important H&SS content areas (e.g., writing, critical reading, social analysis, etc.) at their whim, or they can dabble in a variety of interest areas without developing depth in any. Additionally, because H&SS course requirements usually exist outside of the "engineering" requirements, they are portrayed and perceived as "rounding" courses—a break from the rigor of science and technical courses—and of only limited significance to engineers' academic and professional development. These problems can be exacerbated in institutions where H&SS courses are designed primarily for H&SS majors and, therefore, are not structured to introduce a given intellectual approach to non-majors (i.e., engineering students).

One approach to addressing these types of problems is to structure the H&SS requirements of engineering programs in ways that are relevant specifically to engineering students. Concentrations or minors in H&SS disciplines and related themes (e.g., "engineering and society") are one common way this is achieved, especially at schools predominantly serving engineering students. One such example is the Humanitarian Engineering program at Colorado School of Mines, which includes Jon Leydens, Juan Lucena, and Jen Schneider among its affiliated faculty. Its approach seeks "to balance technical excellence, economic feasibility, ethical maturity and cultural sensitivity" by structuring H&SS electives (and, in some cases, even technical engineering options) to provide depth of coverage (and associated certification) for interested students. Among H&SS electives, Humanitarian Engineering students can take two courses—Engineering and Social Justice and Engineering and Sustainable Community Development—which challenge them to critically analyze their technical program requirements, especially senior design, using a social justice lens. An especially unique aspect of the Humanitarian Engineering program is the menu of depth options available to students, which include: Area of Special Interest (12 credit hours); Minor (18 credit hours); and Certificate Minor (27 credit hours) (CSM 2012).[7] Among the more intensive offerings, the Certificate Minor program integrates selections of technical, liberal arts, and business courses in a sequence that culminates with an intensive capstone humanitarian engineering design project.

2.4.2.2 Social and Technical Integration in Engineering Design

Extending the logic of Catalano's social-justice-based engineering course modules, Rensselaer's interdisciplinary Program in Design and Innovation (PDI), which I direct, highlights and extends the integration of social and technical dimensions of engineering problem solving, specifically in the context of design for underserved communities and sustainability. PDI employs a dual-major strategy, which simultaneously enables structuring the H&SS content for engineering students and creating a series of sequenced, interdisciplinary design studios. Students emerge from the

[7] For reference, a typical US engineering program entails roughly 130 total required credit hours of coursework, with roughly 24 of those credit hours historically dedicated to H&SS content.

program with a Bachelor of Science dual-major in engineering (usually mechanical engineering) and "design, innovation, and society," a studio-based, liberal-arts design degree.

PDI's five design studios (20 credit hours) integrate social and technical dimensions of engineering using a wide-angle approach to design decision making, which includes systematic consideration of (a) users' needs, expectations, and assumptions; (b) markets and their role in directing technology innovation; (c) organizational constraints and opportunities; and (d) a range of cultural values and assumptions that impact students' understandings of both social problems and their appropriate solutions. Social dimensions are considered *simultaneously* with more traditional engineering design content, including: (e) innovative technology applications; (f) structured design strategies (e.g., concept divergence and convergence, decision matrices); (g) product specification and development processes; (h) prototyping and manufacturing techniques; and (i) end-of-life material recovery opportunities.

Other facets of PDI help ensure that social and technical dimensions of design are treated equally in students' design work. First, all PDI design studios entail interdisciplinary instruction: Some studios are taught by interdisciplinary faculty teams and others by instructors with training in both social and technical domains. Second, engineering students in the program are also joined in the studio by business students and communications/graphic design students, all of whom are pursuing the same "design, innovation, and society" dual major. Third, the design, innovation, and society major structures remaining H&SS requirements (an additional 20 credit hours) around the social dimensions of science, technology, and design, so all PDI students have some depth in social science analysis beyond that which is included in the solutions-focused design studios. While PDI engineering students still receive the majority (86 of 129 credit hours) of their total load in traditional math, science, and engineering courses, the PDI content is both well distributed over the curriculum and considerably more focused and intensive than the standard H&SS requirement for engineering students.

PDI opens students to social-justice considerations in three ways. First, in several of the interdisciplinary design studios, students work on projects with explicit and considerable social justice components, including global inequity, social and economic marginalization within well-off societies (e.g., of women, the disabled, the elderly, children, the poor, etc.), and environmental inequities. Second, by accentuating the sociotechnical dimensions of engineering problem solving, PDI emphasizes how the "technical" is always also "political" in that engineering projects disproportionately serve some groups over others and engineering practices legitimize some groups' perspectives and exclude others. Third, PDI provides the foundational social and contextual analysis skills necessary to interpret power imbalances in engineering practice and the social world more generally.

The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Fig. 2.1 ABET Engineering Program General Criteria 3: Student Outcomes (ABET 2012)

2.4.3 Institutional Initiatives

The high degree of social-justice oriented innovation in pedagogy and, to a lesser extent, curriculum development is partly driven by the institutional requirements that structure most engineering programs. Such requirements include those imposed variously by individual educational institutions on themselves as well as those imposed across many or all engineering programs in a given setting. ABET, for example, accredits engineering (and related) programs in the United States and, increasingly, internationally, having accredited over 2,000 engineering programs as of 2010 (ABET 2010, 37). Similar accreditation institutions exist in other contexts (see, e.g., Kabo et al. (2012) for a comparison of engineering accreditation requirements in Australia, China, Sweden, and the United States).

Oftentimes, pedagogical and curricular experimentation is motivated by institutional *constraints*, which require innovative approaches that work around conventional ways of educating engineering students. The institutionally embedded separation between technical content and everything else, for example, provided the negative model that inspired the Program in Design and Innovation at Rensselaer. At least within the US context, this separation was and remains deeply embedded in specific educational institutions' structures as well as ABET accreditation practices (even as ABET's formal accreditation requirements have been relaxed to foster experimentation). With this backdrop, the founders of PDI took it as their primary goal to integrate across technical and social domains.

Given their broad influence, accreditation requirements play an important role in enabling or constraining engineering program experimentation. Many experiments in engineering education in the United States, for example, draw on ABET's

Engineering Criteria (EC) 2000, which include the oft-cited "General Criteria 3: Student Outcomes" (see Fig. 2.1).

Taking these criteria as important but incomplete, in the wake of the United States' ouster of Saddam Hussein's regime in Iraq, George Catalano has proposed three targeted modifications of these criteria in order to promote peace within engineering:

1. Promote peace through the development of an individual plan for the lifelong cultivation of an awareness of the interdependence of all and of the qualities of compassion, caution, and reflection.
2. Promote peace through an improved understanding of other cultures.
3. Promote peace through employing the principles of peaceful conflict resolution. (Catalano 2006, 403–405)

Another response has been taking ABET's Criteria 3(a)–(k) as an invitation to experimentation. Since fundamental EC 2000 requirements are articulated as student learning outcomes, as opposed to listing required content distribution for example, they have facilitated diverse experiments that test for degree-of-achievement of the various outcomes under different educational conditions (Olis et al. 2004). Important in the context of social-justice-based experimentation is the extent to which "social" dimensions are included as general program requirements: Unambiguously in (c), (f), (h), and (j), but also implicitly in (d), (g), and (i) as well. Maria C. Ramírez of Universidad de los Andes and ISFC (as discussed above), for instance, has systematically leveraged ABET criteria in making space for ISFC project work within the engineering curricula at Universidad de los Andes. Because Universidad de los Andes administrators promote a vision of the institution as meeting ABET-equivalent requirements, Ramírez's work has found success where it otherwise might not have.

While ESJP members did not participate directly in the formulation of EC 2000, they have been active at the Frontiers in Education conferences and within the American Society for Engineering Education, especially the Ethics Division and the Liberal Education/Engineering and Society Division. Similarly, Caroline Baillie, now at the University of Western Australia, has been active in reform efforts of Engineers Australia's accreditation requirements.

One final and notable area of institutional reform is at the US National Academy of Engineering. With the collaboration of Juan Lucena and others, Rachel Hollander put social justice on the NAE map, as noted in the Introduction above. As Director of the Center for Engineering, Ethics, and Society, Hollander hosted the 2008 workshop, "Engineering, Social Justice, and Sustainable Community Development." This event was followed up a year later at the annual meeting of the Association for Practical and Professional Ethics, whose theme was "Engineering Towards a More Just and Sustainable World." While these activities are not connected directly to specific educational reform efforts, because of the high status of the NAE among engineering educators especially, they pave the way for systemic reform into the future.

2.5 Professional Reform Strategies

In addition to engineering education reform, members of ESJP also have been active in reform efforts directed at the engineering profession more broadly. These reforms include a range of attempts to influence how engineers think about their work and its relationship to social justice. Most notably, ESJP members have employed professional networking strategies to this end, with the ESJP network itself the epitome of that strategy, but with a series of additional networking activities existent as well.

Not surprisingly, ESJP members also have been active in the scholarly effort to reform conceptualizations of engineering, that is, what engineering is understood to be and what is understood to exist outside of engineering proper. Alice Pawley (2012) explores such boundaries around engineering explicitly. Using feminist boundary theory, she shows how the boundaries typically drawn around engineering—especially as high-tech, big-corporate, for-profit—play into gender stereotypes that exclude women's participation.

2.5.1 Networking

ESJP is probably most clearly defined by its professional-networking and community-building activities. From the beginning, ESJP annual meetings have served to connect interested scholars, educators, and practitioners, with increasing representation by practitioners over the past few years. Practitioners have come from a mix of private-sector and non-governmental organizations, including many engineers involved in social and economic development work in poor communities across the globe. The meetings have also deepened the collaborative efforts of the participants, creating a ready-made, interdisciplinary resource pool, especially valuable for academic projects.

In addition to the annual meetings, the ESJP website created an opportunity for collaborating on a community-wide project as well as a need for hashing out a common vision for the group. Usman Mushtaq, who serves as Webmaster and Editor, among other roles, facilitated the creation of the site and then ensured content was continually added, helping to disseminate the thinking and values of the organization and extending the network. Specific networking resources have also been included on the website, including a bibliography of relevant scholarship and multiple issues of ESJP's 'zine, *Reconstruct*.

While an entirely ordinary dimension of professional association, the significance of ESJP's role in fostering a community with common research interests and creating an environment supportive of critical, but open conversations is worthy of note. At their home institutions, some ESJP members are or are nearly sole practitioners of social justice integration in their research and/or teaching. Feedback from the annual meetings consistently suggests that participants experience tremendous reassurance in their thinking and commitments. Some participants even have stated that, although they have no intention of developing a related research agenda, they prioritize attending the meeting because it is so deeply engaging and motivating.

The support and recognition functions of ESJP also fosters integration of social justice work into the research output of the academic participants, as ESJP-themed conference sessions, research grants, and publications deepen existing connections and extend the network. The existence of the network, and the various, intertwined collaborations it has enabled, also provides common ground for participates to articulate social justice commitments outside ESJP proper, as was apparent at the 2008 NAE workshop described above.

As the sum total of ESJP research output grows, it also produces a legitimacy structure for incoming participants to draw on and point to as they attempt to carve out their own research niches in the field. Beyond the ESJP annual meeting and the extensive related publications by ESJP participants, the group has experimented with connecting interested engineering practitioners with communities in need (e.g., Baillie's work with Waste for Life), has conducted outreach at other organization's professional meetings (e.g., distribution of the 'zine, *Reconstruct*, at ASEE annual meetings), and has initiated its own open-access journal (first published Spring 2012).

That journal, the *International Journal of Engineering, Social Justice, and Peace*, is the culmination of years of effort to establish and advance ESJP's Internet presence and disseminate related work globally. The goal of the journal is to serve as inspiration and support for those who promote engineering for social justice and peace by disseminating empirical research, careful thinking, and creative practice. The journal's defining characteristics are its unique focus; its deep interdisciplinarity; and its free-access, open-source format. Edited by Jens Kabo, Usman Mushtaq, Donna M. Riley, and myself, with Queens University librarian, Nasser Saleh, serving to shepherd the journal through publication requirements (e.g., ISSN registration, indexing, etc.), the 2012 launch issue included five peer-reviewed articles on engineering and social justice,[8] which derived from the 2010 ESJP annual conference and the research grants described in the following section.

2.5.2 Re-conceptualizing "Engineering"

All of ESJP's current coordinating committee members are engineering or engineering studies scholars, so it should not be surprising that much of the work of the group has a strong conceptual dimension. Although motivated by a desire to improve on-the-ground engineering practices (and the education that prepares for it), much of ESJP's output is scholarly—inquiring into the assumptions, values, and structures shaping both engineering thinking and its practice. Widely represented across the group is attention to the "dominant worldview" surrounding engineering—the

[8] Armstrong and Baillie (2012), Valderrama Pineda et al. (2012), Barrington et al. (2012), Nieusma and Blue (2012), Leydens et al. (2012).

common understanding of engineering shared by both most engineers and the wider public—and how it contributes to a sense of inevitability surrounding engineering practices and outcomes. By challenging certain assumptions undergirding the dominant engineering worldview, ESJP scholars seek to create more space *within* engineering discourses for questions of social justice.

Notable in terms of scholarly output by ESJP members is the Morgan and Claypool book series, Synthesis Lectures on Engineers, Technology, and Society, edited by Caroline Baillie. The series includes a long and rapidly growing line-up of titles, which includes publications by many ESJP members:

- George Catalano, *Engineering Ethics: Peace, Justice, and the Earth* (2006)
- Caroline Baillie, *Engineers within a Local and Global Society* (2006)
- Donna M. Riley, *Engineering and Social Justice* (2008)
- Juan Lucena, Jen Schneider, and Jon Leydens, *Engineering and Sustainable Community Development* (2010)

Also recently published by Purdue University Press is *Engineering and Social Justice: In the University and Beyond* (2012), edited by Caroline Baillie, Alice Pawley, and Donna M. Riley.

ESJP community members have also won major grants for research into engineering and social justice, which have investigated various engineering and social justice communities (including historical ones), how engineering-and-social-justice advocates frame their work, and the opportunities and barriers that exist for engineers to get involved in social justice issues. Examples of such grants include Donna M. Riley's NSF CAREER Award on liberatory pedagogies; Juan Lucena, Jon Leydens, and Jen Schneider's NSF grant, "Engineering and Social Justice: Research and Education of (In)commensurable Fields of Practice"; and Caroline Baillie's Australian Teaching and Learning Council grant, "Social and Environmental Justice in Engineering Education." More research is sure to follow[9] as the engineering and social justice community grows in concert with efforts surrounding international development, sustainability engineering, and grand-challenge-type initiatives.

One key assumption that is challenged across ESJP scholarship is the conceptually tidy distinction between social and technical dimensions of engineering practices, where the technical dimensions are understood to be "real engineering" and the social dimensions (mere) contingencies or marginal considerations. This assumption results in a tendency to seek an idealized engineering practice that is abstracted from the context in which it takes place. Whether or not philosophically justifiable, this approach is predicated on the assumption that questions surrounding the context of application of engineering expertise are secondary to technical questions, and that as long as one is not "lying, cheating, or stealing," a competent engineer need not direct much attention to context.

[9] In fact, all three of the aforementioned grants have garnered considerable interest in the research community, with requests for sharing proposals and derivative projects being framed, in some cases with grant recipients serving as advisors on those derivative projects.

ESJP scholars take issue with this assumption in particular, both in terms of its veracity and in terms of its impact on engineering training and decision making. Since context fundamentally determines what are considered to be desirable engineering goals as well as what is possible to achieve (organizationally, politically, financially), stripping social dimensions from "engineering" knowledge renders it powerless in responding to unjust outcomes. Only by integrating context as part and parcel of engineering practice can questions of social justice be seriously addressed. (See Chap. 4 by Cech in this volume for an in-depth analysis of the split between the technical and social.)

Muddying the social-technical distinction to better integrate social justice considerations within engineering offers numerous opportunities for ESJP members to link up with engineering-reform scholars working in overlapping circles. One noteworthy such community investigates the domain of engineering ethics, but takes an expansive approach to ethics, one that includes what Joseph Herkert has famously labeled "macroethics" in engineering, which grapples with engineering's "collective social responsibility" (2001). Similarly, much work in Engineering Studies (as a research community and the name of that community's flagship journal) takes an interventionist approach to scholarship on engineers and engineering (see, e.g., Downey 2009). And finally, given that a central thrust of Science and Technology Studies (STS) scholarship challenges the social-technical binary, STS broadly has "important implications for understanding the responsibilities of engineers" (Johnson and Wetmore 2008, 577). Each of these scholarly approaches, as well as a long list of others, offers the possibility of productive engagement and expansion of EJSP work.

2.6 Conclusions

Taking the numerous initiatives carried out by ESJP members as a whole, we see a range of overlapping and mutually reinforcing strategies to reform engineering. That ESJP is a network of like-minded individuals collaborating to promote a (mostly) shared vision of social justice within engineering is clear. Additionally, however, we see an emergent if not deliberately coordinated set of reform strategies that target diverse audiences at multiple scales of intervention. This "systems level" approach to reform is consistent with how ESJP members understand engineering-and-social-justice problems to begin with, so it is appropriate that it would be represented in ESJP reform efforts as well.

A social-justice lens to engineering helps open up the discussion of what engineering is and ought to be. By looking at the range of approaches ESJP members use to bring social justice more centrally into engineering, this chapter attempts to move beyond analytic assessment of competing views of engineering—however important such assessments may be—by providing a framework for thinking and action useful to those who would advocate greater attention to social-justice questions by engineers or any similar reform agenda.

Ultimately, the analysis suggests that advancing social justice in engineering entails a variety of approaches: designing solutions to developing-world poverty, entering the halls of the NAE to promote greater attention to social justice issues; and opening up the boundaries around "engineering" knowledge to challenge the primacy of the technical core (without rejecting its essential contribution) and to accept, in principle and in practice, the various social facets of engineering work as equally constitutive of "engineering."

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Chapter 3
Power. Systems. Engineering. Traveling Lines of Resistance in Academic Institutions

Donna M. Riley

Abstract Having lived the injustices of engineering education as usual, as a first year professor I quickly became concerned with how students related to one another in my engineering thermodynamics class. At the suggestion of a friend, I picked up bell hooks's *Teaching to Transgress;* this began 10 years of transforming the course using critical, feminist, and engaged pedagogies, a process that required change in content as well as approaches to teaching and learning. I teach technical material alongside its critiques. Students analyze energy flows in engines and refrigeration systems while they ponder how power constructs scientific knowledge, investigate the ethics of energy disasters at Fukushima and the BP Deepwater rig, uncover contributions to thermodynamics outside of Western Europe, and explore North-South conflicts over action on climate change. A subsequent book project hopes to encourage other thermodynamics faculty to teach modules from this course, raising a new set of questions about the potential for transformation and co-optation. Doing this work has revealed both the importance and the limitations of teaching toward social justice in a core engineering course. In this chapter I reflect upon the institutional considerations of course development, from ABET accreditation and federal funding to departmental student and faculty cultures of resistance, revealing both "how I got away with it" and what the costs and benefits have been personally and professionally.

Keywords Thermodynamics • Critical pedagogy • Feminist pedagogy

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3.1 Introduction

The intent of this chapter is to focus on institutions, and their practices, and the ways in which they can facilitate and hinder classroom initiatives around social justice. I am not a scholar of organizations; I do not formally study institutions, and yet I struggle within them every day. My hope is that this experience and my reflections here will nonetheless add something to the conversation and be useful to others who, like me, are seeking to transform their engineering classrooms toward social justice.

I have written a great deal elsewhere on the curricular and pedagogical details of transforming my thermodynamics course (Riley 2003; Riley and Sciarra 2006; Riley and Claris 2006, 2008; Riley et al. 2006a), and thus will not provide much depth here on the substance of my course transformations. Instead I will begin with a personal narrative about my experience of engineering education as usual, because it has so deeply influenced my attempts at transforming my own classrooms. Then I will describe a bit of the process I went through in my own teaching and learning, with a view to the institutional practices that influenced this process. I will seek to enumerate the obstacles to this work, and end with some reflections on the possibilities for change in teaching social justice in conservative institutions.

3.2 Thermo as Usual

I attended an undergraduate institution built for elite White Anglo-Saxon Protestant men that had decided two decades prior to my arrival to admit women, over vehement objections from alumni. Its stated rationale was not so much a principled commitment to educate women, but more an argument of urgent necessity: that they were losing men to coeducational schools and needed to admit women to attract quality men (Patterson 1968). In my time, the coeducation process was not yet complete; a decade-old lawsuit finally forced the last 2 of 13 eating clubs – the central social hub of the campus and the place where the large majority of juniors and seniors ate their meals – to admit women (Frank v. Ivy Club 1990). There was open suspicion of women and minorities admitted as "affirmative action cases" – a mythology so vicious on- and off-campus that admissions practices ultimately had to be explained and defended publicly by our former president (Bowen and Bok 1998). In this environment, anyone who wasn't a wealthy straight white able-bodied male was bound to encounter obstacles, and all the more so in an engineering major. At the same time, this was an environment in which change *was occurring* in the direction of social justice, and I was able to participate in those changes, as well as observe and experience their unfortunate backlash.

It was here that I learned two important lessons for the work I am engaged in now. First, I experienced a stark contrast in pedagogy between my engineering and non-technical courses, and became very curious about this difference, questioning why engineering couldn't feel more like my other courses. Second, I survived the hostile environment in engineering through my involvement with campus activism, where I learned a great deal about how to make change in institutions, and the power of relationships in resistant communities.

3.2.1 Thermo and Gnosticism: A Tale of Two Esoteric Subjects

I learned thermodynamics as an undergraduate chemical engineer in traditional lecture-based classrooms. My professors in both semesters of thermo wrote notes on the chalkboard, which we copied into our notes, rarely asking questions, never working problems ourselves, and struggling outside of class to understand the material via problem sets. The course content was all extremely abstract, with rarely an industrial application, let alone social context. Our tests in the first semester consisted of two or three questions: "Derive this. Start here. Derive that. Start there. You have 80 minutes." They came back with a red letter grade on it, no explanations or feedback. In the second semester, where we were doing "applications," we were working with systems of separations processes we had never ourselves seen or experienced, and could visualize only as process flowcharts. I experienced my professor as I do an untrustworthy dentist: "does he really have my best interests at heart? How do I know he isn't a sadist? Isn't there a more humane way to do this?"

My non-engineering courses by and large could not have been more different. For example, in an upper level religion seminar on Gnosticism with Elaine Pagels, we read and wrote a weekly two page reflection on the reading, and she facilitated a discussion based on our reflections, drawing us out as scholars in our own right. I wondered then why my engineering courses couldn't be more like my courses in the humanities and social sciences. I could not yet articulate how the construction of engineering courses reflected and perpetuated a certain order of things in engineering, but I knew I felt both competent and welcome in the religion course, despite being a non-major and having only one of the prerequisites. My ideas were valued even if they weren't necessarily expressed in the right jargon or steeped in historical knowledge of late antiquity. In chemical engineering, I frequently felt both incompetent and unwelcome, despite holding my own academically.

Gnosticism is at least as esoteric a subject as thermodynamics. And yet I found my term paper in the religion course to be far more relevant to my life than thermo problem sets. I examined the life of Melania the Younger and other female ascetics in the early Church. I analyzed their gender transgressions – they literally transformed their bodies through the ascetic practice of not eating, ceasing signs of femininity like menstruation, or reducing the appearance of curves that marked them as women. This performance of androgyny gained them acceptance in Church leadership.

I myself had fully embraced the grunge trend, dressing in oversized male clothing, a practice that reduced the level of negative attention I might receive as a female engineering student, and more generally as a female student at Princeton. I found I was accepted as an engineer by my peers, but at the cost of perceived womanhood. One friend remarked to our study group, “The E-Quad is totally devoid of women” – and when I cleared my throat, he said tactlessly, “well, good looking ones anyway.” I actually don’t believe he was commenting on my appearance – I think he didn’t even see me as someone whose appearance would be commented on, as I was in some “other” gender category. Seymour (1995) documented this phenomenon more broadly in her ethnography of engineering undergraduates – both the practice of women dressing to avoid unwanted attention and the practice of men categorically seeing female peers in engineering as un-datable. That these clothing choices also expressed my emerging queer identity and that I was ambivalent at best about dating male engineers adds another layer of complexity to my experience – it was both comfortable and brought new and different risks of homophobic harassment.

If Melania the Younger could help me understand what I was going through in engineering, I wondered, why couldn’t my thermodynamics classes have provided similar insights? Could they at least have had some professional relevance to my interest in the environment? It would be years before I saw how the instruction I received on the fugacity[1] in thermo could have included application to environmental contamination (Mackay 1979), and the study of heat engines could have included a discussion of climate impacts (Warhaft 1997).

3.2.2 Learning to Stay and Fight: Lessons from Social Justice

I almost became a religion major sophomore year when my New Testament professor John Gager recruited me with a strong argument for a liberal arts education. It was too soon, he said, to pursue a professional degree, and I should take a broader range of classes, learn more about the world, and about myself. But the structure of engineering required an undergraduate commitment, and (at least as I understood it) I couldn’t enter the profession later without taking a second bachelor’s degree.

I was clear on my educational mission: to get a well-rounded but scientifically based education that would enable me to work on environmental problems. While on the one hand the lack of applications in my engineering education meant that I did not always see how relevant my education was to environmental problems, there was not yet a major in environmental studies on my campus. By my junior year I found I could apply my chemical engineering knowledge on an environmental research project (albeit outside the department). This was also my only opportunity to work with a female mentor.

The strength to stay in engineering, however, came largely from my campus activism. I was able to make sense of my experiences, stand up and fight back against individual acts of hostility and against the system that produced them, perhaps mitigating the toll of these microaggressions (Pierce et al. 1977). I was able to

[1]The fugacity is a quantity used to characterize the chemical equilibrium behavior of real gases.

contextualize these experiences in terms of power and privilege, and participate in education and activism that targeted these issues.

Even as I became increasingly aware of engineering's relationship to social injustice, I maintained (and still maintain) an idealistic notion that engineering can be directed toward just purposes. It may have been my own coming out struggle that enabled me to embrace rather than abandon this contradiction and its many dissonances. To be bi meant embodying a contradiction in refusing the hetero-homo binary. Moreover, I came out bi as a practicing Presbyterian, a faith tradition then battling mightily over a Church report on sexuality (Presbyterian Church USA 1991) that argued for the morality of relationships based on their quality rather than forms of legal marriage or partners' anatomy. I drew strength from that report as I moved from a home church that was decidedly anti-gay into a wider denomination with open and affirming communities. People were baffled that I didn't leave such a homophobic institution.

Ultimately, if I believe in social construction of engineering, or of religion, I also believe that institutions can be de-constructed and re-constructed through social action. Thus engineering (or religion) is as Boal (1985) said of theatre, a weapon we must fight for, because it can be used in the service of the ruling interests, or it can be used in the service of resistance. And so I stayed to fight, embracing all of these disparate identities: woman, engineer, queer, Presbyterian.

As an undergraduate activist I was perhaps most dismayed by the absence of discussion of campus and current events in my engineering classes. The Montreal Massacre at the Ecole Polytechnique, where 13 female engineers and one female staffer were shot dead by a gunman out to get "feminists," (Chalouh and Malette 1991) went unremarked upon by all faculty in my department, as if it did not happen. There was a similar silence in engineering on the campus's annual Gay Jeans Day, in which LGBT people and allies would wear jeans on National Coming Out Day to show support for LGBT people. The event was advertised more widely and broadly than any other, because one goal was to have every member of the campus community face a choice about what to wear, creating for one day, in a tiny way, a process of questioning akin in some respects to coming out. Our chemical engineering faculty never wore jeans, and seemed oblivious to the entire thing. Meanwhile, homophobic engineering students went out of their way to wear suits, or khakis. This deliberate anti-gay statement made the engineering classroom an overtly hostile place for me as a bi student coming out, with my professors standing by in silence, either assenting or clueless. It would be another 20 years before the engineering education community would even entertain a discussion of the experiences of lesbian, gay, and bisexual undergraduates in engineering (Cech and Waidzunas 2009), sadly affirming how little has changed for queer students in engineering.

One of the things I learned through my activism in the LGBT movement, then focused so acutely on visibility, is that one's very existence is an act of resistance. My daily presence in class became for me an act of protest by survival – or in the problematic parlance of our present day, an occupation.

So it was that I smiled to myself at my Polymers professor's unconscious talk of "free radicals" or my encounter with LeChatelier's Principle in Reactors: any change in the status quo of a system brings on an oppositional response. You're telling *me*! However, none of my classmates got the joke. Still, a colleague in Mechanical Engineering joined me in gender activism at the Women's Center. Two engineers a couple of years ahead of me compiled a volume of alumnae's experiences in engineering (Ng and Rexford 1993), to which I contributed my own reflection as a student. There was a small group of LGBT students and staff with connections to engineering, including a gay man who worked with me on every problem set, but we weren't organized as queer engineers. I relied on a large number of people outside of engineering – roommates in political science and anthropology, activists from across the campus, and professors and graduate students in my non-engineering courses – who helped me understand my situation and survive. I learned from them how essential relationships are to the work of resistance.

3.3 Transformative Processes

Though I could not possibly have imagined it as an undergraduate, I found myself in the spring of 2002 teaching engineering thermodynamics to a class of women[2] engineering students at Smith College. As a doctoral student I had learned a little about pedagogy through the teaching and learning center at Carnegie Mellon, but these lessons were based in mainstream cognitive psychology of learning – Bloom's taxonomy and the like. I still had not cracked open the conundrum of power systems in engineering classrooms, though I certainly felt their effects. I had vigorously pursued a number of social justice causes in graduate school (in addition to campus activism these included the Lesbian Avengers, abortion clinic defense, needle exchange, and serving on both local and national boards of LGBT Presbyterian groups), but could not make them connect with engineering, despite the fact that there were fellow engineers in every single one of these groups (save needle exchange).

A few weeks in to teaching thermodynamics at Smith, things were not going well. The worst of it was that I saw students in the back of my classroom disengaged, while students in front monopolized my attention. That these students in the front were more homogeneously white, middle class, and heterosexual than those in the back did not escape my attention. I was terrified to be perpetuating the experience of how I was taught, to be reproducing power systems I found so painful and obstructionist in my own engineering education.

[2]Smith continues as a women's college, while its students hold a range of gender identities including male, female, genderqueer, and more. In that spring semester in 2002, to my knowledge, my students all identified as women, though since that time some of the students in that class as well as in future offerings of the course have expressed non-conforming gender identities.

I asked for help from a colleague of mine who taught Sociology at Grinnell College, someone I knew through queer and feminist activism. It was a vague and naïve question – why can't I make my engineering class more like my non-technical courses in undergrad? I had noticed in my experience in Elaine Pagels's class that we sat around a table facing one another. In engineering classrooms we did not. I do not remember now whether the desks were bolted down, but they might as well have been since they were never in any arrangement other than straight rows facing front. But I knew there had to be more to it than seating arrangements.

My friend recommended bell hooks's (1994) *Teaching to Transgress* and I was transfixed. The book identified clearly for me how classroom interactions and presumptions of knowledge reproduced structures of power. Relationships are central to hooks's pedagogy, and creating classroom spaces that enable the possibility for more just relationships between teacher and student, and for individuals in community. At the same time it was clear that so much of what bell hooks accomplished in her classrooms was supported by course material that dealt directly with power and privilege around race, class, and gender. I was unsure how to take these goals into an engineering classroom. How could one teach about difference, power, and privilege when the course topics were entropy, enthalpy, and engine cycles? How much room could there be in the land of objectivity for the authority of experience and personal narrative?

Below I describe the process of transformation that took place, with a focus on institutional factors influencing the development of pedagogy and curriculum in the thermodynamics course. Early attempts were small and simple, and then two central distinctive elements of these pedagogies came to the center for me: power and epistemology. Focusing on power and epistemology separates the pedagogies I employ from mainstream active learning practices; it makes the difference between pedagogies that work for social justice and those that maintain the status quo.

3.3.1 First Attempts

I started small. I immediately changed the seating arrangement in my class, and discussed this change with the class. I then asked students to present textbook material to each other rather than having it come from me via powerpoint. I asked them to find their own "Melania the Younger" assignment – that is, an individual exploration of thermodynamics that would have personal relevance to them – in a project called "Thermo to Life." This was an open-ended mini-project where students picked a phenomenon of interest from their lives and explained the thermodynamics of it using both thermodynamic theory and numerical calculations to model the phenomenon. Students chose projects ranging from running track to building an igloo; from road trips to double-chamber bongs.

hooks stressed the importance of de-centering Western civilization (now we might say the global North) and the male canon. I knew the engineering curriculum was so very Western[3] that people who teach it didn't even have a consciousness about that. But because I was at a liberal arts college, I was able to obtain an internal fellowship to hire a student who explored for a summer what some non-Western ideas in thermo might be. We came up against a distinction between engineering and technology; finding descriptions of non-Western technology was no problem. But, if there is no theory, it is *merely* technology; one can still use Western concepts to analyze non-Western technologies, but what is the non-Western thermo theory? Is theory so narrowly defined to preserve engineering's Western tradition? Or is it merely evidence of the limits of my own training, lacking the linguistic and cultural knowledge to find and read texts that might contain these theories?

I attempted to collaborate with scholars outside my discipline, including a Native Studies scholar who shared Gregory Cajete's (2000) *Native Science* with me, but she left Smith (underscoring the importance of institutional support and welcome for faculty of color). At that time I did not have connections or support for cross-institutional collaborations on this topic. As it was, I hesitated to adopt ethnoscience in thermodynamics without a collaboration of some depth because I wanted to adequately guard against essentialism and co-optation of cultural traditions among students with limited backgrounds in ethnic studies. I did proceed with an open-ended problem analyzing (using Western thermo principles) a Nigerian pot-in-pot evaporative vegetable cooler (Elkheir 2004) and a passive air conditioner operating on similar principles in India (Wong 2003).

Smith has a designated day of education on race in honor of Otelia Cromwell, its first African-American alumna. Using this event as an opening, I created an assignment to observe the day by identifying women of color in Thermodynamics. On one level, this exercise is both easy to implement in a course, and insufficient in its consideration of race – requiring merely a biography of a woman from a different racial-ethnic background from the student writing about her reveals nothing (necessarily) about power and privilege. And yet, the process of completing the assignment raises some more interesting questions: why is it so hard for students to find women to profile? It is *not* explained simply by the dearth of women in engineering. Looking more deeply, it is a lesson in how boundaries of the field and language we use to describe our work are gendered and raced; search terms like "energy" reveal far more women of color than "thermodynamics" does. With the perspective of historical analysis, these boundaries can sometimes be easier to locate: women's work in engineering in the twentieth century was often thought of as "home economics" despite equivalent technical preparation and rigor (Bix 2002). The assignment also teaches students about how class, race, and gender affect social networks; often students are more aware of prominent figures from their own racial-ethnic background, and asking a peer can sometimes lead to identification of new individuals to profile.

[3] I continue to use Western here rather than the more contemporary North-South language in recognition of the historical setting in which thermodynamic theory and the non-Western technologies I have incorporated in my class were developed.

As I was struggling with these transformations, bell hooks came to speak at Smith. That I work at an institution that would invite a prominent feminist theorist and expert in critical pedagogy, and is small enough that I could approach her one-on-one, is perhaps rare among schools that house engineering programs. I asked her if anyone was implementing her pedagogies in the sciences or engineering. She said there were a few, but couldn't recall their names at that moment, and remarked that scarcely anyone was writing about it, and that I should promise to write about my experiences. I promised I would. This writing ultimately led to a successful grant proposal that funded me to implement and assess pedagogies of liberation[4] in engineering thermodynamics and other courses in engineering at Smith.

As supportive as my encounter with hooks was, I had an equally non-supportive encounter with a prominent academic in engineering education around the challenges of de-centering Western civilization/the global North in engineering classrooms. In 2006 at the American Society for Engineering Education (ASEE) conference Henry Petroski gave the Distinguished Lecture for the Liberal Education Division on the importance of integrating history into engineering courses – and I couldn't have agreed with him more. But my own experience in integrating the history of thermo into my course was that the histories that match textbook material are based entirely on the accomplishments of men in nineteenth century Western Europe. Too often these histories are additionally stripped of social and political context that might complicate the neat linear narrative of individual discovery.

Following a question from Alice Pawley about the value of social history, which Petroski agreed was important, I remarked that I taught the history of thermodynamics using a book that students found compelling and accessible (von Baeyer 1999), but also lamentably exclusively European and male. I commented that it would be great to have a similar resource that was broader in its perspective, as my student researcher had uncovered histories of contributions to thermo in Ancient China, India, and the Near East (Al-Hassan and Hill 1986; James and Thorpe 1994; Taylor 1949; Stanley 1993). Petroski, rather than agreeing that this is needed, commented that the contributions of the Chinese had been "greatly exaggerated," and further stated that African Americans and women made up only 5 % of nineteenth century US patents. (Actually, this is an impressive number considering the resources required to obtain a patent and that most women and African-Americans were excluded from institutions of engineering education and practice!)

More shocking to me than this response, however, was the reaction I received from a female bioengineering graduate student in the audience, who introduced herself to me only to say that I had confirmed her worst suspicions about what we were doing at Smith. She felt I had been terribly disrespectful to Petroski, and that I had a

[4]The terminology pedagogies of liberation is one used by Paulo Freire, critiqued by white feminists based on the history of male dominance in liberation movements and the question of who decides who is being liberated. But hooks (1994) defended liberatory language as meaningful for many women of color. There is no one term I know that can encapsulate the pedagogical approaches I use. My intention is to be sensitive to the critiques presented in critical, feminist, decolonizing, queer, and other pedagogies for social justice.

political agenda that had no place in engineering. The power dynamics here are multi-layered. Her expectation for the behavior of women engineers in the presence of senior male colleagues was shaped by her position as a white female graduate student in a large research institution. My polite questioning of Petroski's statements seemed entirely in bounds to me, if a bit risky for an untenured white female professor at a small women's liberal arts college. For her, my actions were beyond the pale; I am uncertain if only silent assent could communicate proper respect, or if it was talking about the absence of non-Western, non-white, and non-male perspectives that was the problem. At the same time, angrily chewing *me* out did not seem to breach decorum for her. These interactions reveal something of the forces that work to marginalize efforts to de-center Western civilization, teach diversity, and work for social justice in engineering classrooms.

3.3.2 Teaching About Power

Meanwhile, back in my classroom, I was finding that students struggled with my pedagogies, having particular trouble understanding why I was asking them to take on authoritative roles. I realized that they needed a deeper understanding of power to be able to make it a conscious part of our work in class and to be able to make sense of our activities. If the goal of the pedagogies I use is for students to be able to think critically and act reflectively for social justice, they must foster an understanding of power. This required a curriculum change to introduce power explicitly (as something other than work over time, $P = W/t$).

I began to informally call my course Power/Knowledge, after the reading my colleague Lionel Claris had selected from Foucault on truth and power in science (Riley and Claris 2006). Juxtaposing a pedagogy like Freire's with Foucault's conception of power does some interesting work in my classrooms. For Freire, there are distinct groups of the oppressed and the oppressors, those who have power, and those who seek empowerment through resistance. Foucault, by contrast, is interested in relations of power, where imposition goes hand in hand with resistance (Foucault 1982). Feminist critics of Freire (e.g., Luke and Gore 1992; Lather 1991) are concerned critical pedagogy could replace traditional pedagogy as the new classroom hegemony, now demanding that students conform to an ideal of liberation and empowerment. They question who has the right to label another "oppressed" or "empowered." A Foucauldian understanding of power relations is helpful for sorting out the complexities of classroom and institutional interactions, and allows for incorporation of these critiques by contesting and problematizing a binary conception of power and related notions of empowerment or liberation.

In a liberal arts setting, it is likely that even students in engineering have at least heard of Foucault, often from friends in other disciplines. They apply Foucault's notion of power/knowledge to the class syllabus, textbook, and historical readings: Who decided what constitutes thermodynamics? What (and who) did they leave out? They connect Foucault to my pedagogies, understanding the intent to create a learning space where the relationships between power and knowledge, and the roles of teacher and student, are explicitly contested.

At the request of a student, I initiated a lesson on the anniversary of the Montreal Massacre (Riley and Sciarra 2006). Not one to believe everything she read on the Internet, the student approached me to see if I remembered the event. When I told her it had made an enormous impression upon me because it happened my first year as an undergraduate, she asked why the (country's then only) engineering program at a women's college wouldn't learn about it. Indeed, she had a point. And this created a new opening for talking about diversity in the classroom, in ways that incorporated recently developed understandings of power. This activity allowed for more explicit discussions of power, as students readily made connections across race, class, gender, ability, and other dimensions of identity (Crenshaw 1989). This exercise created an opportunity for students to envision and act for social justice with respect to diversity in engineering.

Student engagement with Foucault and the Montreal Massacre would not emerge from conventional adoption of active learning, but are a natural outgrowth of questions of power raised by critical and feminist pedagogies. The goal of these activities is more than student engagement or understanding of the material; it is transformation and social change.

3.3.3 Epistemology: Teaching Material and Its Critique

Learning to think about and work for social justice entails particular ways of knowing, and more important, respect for the validity of others' ways of knowing. The positivist epistemologies that dominate engineering thought are problematic for social justice efforts because they rely narrowly on empirical scientific knowledge and traditional problem solving, where there are only right and wrong answers. It similarly takes a different way of knowing to shift from a "colorblind" approach in which eliminating race from the classroom is "race-neutral" to one where it is acknowledged that "race-neutral" approaches teach white privilege and devalue difference.

I seek to enact these kinds of epistemic shifts in my thermodynamics course and in my other engineering courses by creating a dialogue between the canonical material and its critiques. Challenging the canon is an approach that has been taken up in many disciplines outside the sciences, but these approaches do not always entail multiple epistemological approaches. In engineering, there is no method within the discipline for engaging critiques of this sort; thus it must draw on disciplines that access other epistemological frames, like the philosophy of science, or science and technology studies.

What does teaching material alongside its critique look like? I have written about the details of these implementations elsewhere, including a thermodynamics textbook companion containing lesson plans (Riley 2011). By beginning my course with an introduction to the pedagogies I use, and a reading and reflection on

Foucault's power/knowledge, students are prepared to read histories of thermo in Western Europe with a critical eye. They then are challenged to uncover, in their own research, contributions to thermodynamics outside of Western Europe.

They can also trace the "thematic content of science" (von Baeyer 1999) in the formulation of the first and second laws, and see the ways in which entropy defies the expectations of a scientific theory or thermodynamic property. Entropy does not comply with conservation principles and is ever increasing; thus it is an awkward fit in a balance equation. Even so, "entropy balances" abound in undergraduate thermodynamics textbooks (as do entropy inequalities, which students also struggle to understand).

Ethics questions in thermo then also go beyond an individual approach to ethics that asks, for example, what an energy engineer should do when faced with a conflict between loyalty to employer and honesty with the public. Instead these broader questions probe topics such as the public ethics of investment in nuclear power or fossil fuels, using case studies from energy disasters at Fukushima and the BP Deepwater rig. Students can use a social justice frame in analyzing who wins and who loses in these disasters, or in North-South conflicts over action on climate change. In the case study that connects Fukushima with the BP oil disaster, students consider

> To what extent are energy disasters "business as usual?" Should they be prevented? Can they be prevented? Who is responsible to prevent them? … Do engineers have a duty to design for what cannot be anticipated? …. What are the responsibilities of individual engineers? Of their management? Of energy companies? Of government? Of consumers/citizens? (Riley 2011)

In a case study on the Copenhagen Climate Summit, students ask

> What duties or responsibilities do nations have to one another and to the planet, or the global North to the global South and vice versa? What would the principle of justice require of nations at this summit? What rights apply to nations in this context, and how are these balanced against responsibilities to the international community? (Riley 2011)

I believe this is the change that my peers would view as most problematic, as disciplinary boundaries would suggest that this material is not engineering. Yet it complements the technical material, which I teach more or less intact, even as its sexism, militarism, xenophobia, and heterosexism are called out (Riley 2003). The epistemic shift I ask of my students puts them in a meta-location where they can critique the text and identify its biases rather than commit them uncritically to memory as objective knowledge. Rather than being mystified by entropy, they now have the tools they need to question and discover why it is such a troublesome concept for science and engineering students. They can see beyond a text focused on fossil fuels leading to a climate crisis, and envision an energy future that is not only less environmentally destructive, but also more socially just. As students have reflected in focus groups on the course (Riley and Claris 2006):

> Now I am more critical; critical about the problems we solve, about the issues we cover in class and the discussions we have there also….It was not just the sciences, the technology, and all the math behind it, it was also this other side that helped me develop these critical thinking skills.

> The concepts we learn as students are most likely the ones we will later on be most comfortable with as engineers. This means that the choice of concepts has power not only over individual students, but also over the people whose lives our engineering will influence.

This work again utilizes techniques recognizable to practitioners of active learning but focuses on engaging students at an epistemological level, producing critical thinking and reflective action.

3.3.4 Book Project

I am now involved in a project that encourages other thermodynamics faculty to teach the modules collected in my book (Riley 2011). I have grave concerns about whether faculty will understand the pedagogies involved, and whether they will be able to successfully implement the modules in a manner supportive of social justice aims. I believe the modules can easily be used in classrooms that are reproductive of status quo power relations. In liberative pedagogies relationships matter, and I'm afraid I have not succeeded in conveying these relational shifts through the book. How can a book really listen and engage in critical dialogue with a student regarding their engagement with the material? Without relational interactions that take place regularly in classroom settings, will students develop the same understandings of how power and resistance work?

The entire framing of the project, set by the funding agency, is around dissemination of innovations, using market language to address the problem of faculty resistance to change in engineering education. The grant facilitates some shifting of the forces at work in faculty lives to make it possible for them to test drive some of the modules I've developed, but for most, I do not think it will enable transformation to any great extent – at least not of the sort that leads toward social justice.

I am nonetheless hopeful that for those faculty who are interested in social justice, these modules can prove helpful in sharing curricular ideas and classroom strategies. The funding and prestige of the grant might convince some faculty to attempt making truly transformational shifts. I even hope that some may initially use the modules in traditional settings and later come to recognize, as I did, the centrality of power and epistemology in transforming classrooms toward social justice.

3.4 Institutional Obstacles

None of this work has been easy because it calls attention to structures and practices of power and seeks to resist them. Here, I first elaborate on how institutions can hinder efforts to transform curriculum and pedagogy. Second, I discuss how my acts of resistance are met with assertions of power from students, faculty, and administration, set within these institutional frameworks that work against education for social justice.

3.4.1 Obstacles

Obstacles abound in any social justice project. I describe here those I have been able to identify as the most salient in my efforts to teach transformatively: grades; teaching evaluations; the corporatization of the university; framings of diversity that elide injustice; disciplinary structures in academic institutions; construction of engineering majors, curricula, and textbooks; ABET accreditation; and national priorities for the field of engineering.

Grades are the bane of my existence as a teacher. As Charles Reich (1970) wrote in *The Greening of America* "A judgment, unasked for, is an act of violence; if one met a man at a party, and the man said, 'I'd pronounce you approximately a B-minus individual,' one would recognize how violent the act of judging or grading someone really is." (136) Alternative systems have long existed that involve a dialogue between professor and student about their learning. At my institution I am required by our Faculty Code to assign a grade for each student, and anti-grade inflation policies require that no more than 40 % of students can receive grades of A or A−.[5] While it is possible to involve students in the evaluation process, ultimately, I assign a grade. It is, sadly, the main reason many students go along at all with my implementation of critical pedagogy. Grades are the central motivation for my students, for some the source of their self-worth. For many it represents their life aspirations as they see good grades leading to good grad schools and good jobs, and this creates a deeply troubled relationship with me, resisting my role as grader. I have built into the grading system every behavior I want to see: I want them to reflect, so their reflections are graded. I want them to analyze ethics cases, so these are a significant portion of the grade. For those who do not value reflection or ethics, the fact that their apathy affects their grade produces resentment. For others, they are happy to perform well in these areas for their grade (see Cech's chapter in this volume (Chap. 4) for a critique of meritocracy in engineering education).

Teaching evaluations are the flip side of the grading problem. The pressure is on for me to please students and entertain them in class. To do something they do not like is to risk their wrath, and requires politicking and careful maneuvering. The evaluations themselves do not value the goals of critical pedagogies, do not ask about the extent to which classroom power relations are leveled, the extent to which students become reflexive actors for social justice in their world. Instead they reinforce the banking system of content delivery, asking whether I was clear (I most definitely was not if I asked them to explain material to each other). I am expected to download information to students' brains and ask them to regurgitate it for a grade.

The corporatization of the university and the framing of students as customers work directly against my pedagogical goals. First, the implementation of neoliberal ideas in managing labor within the institution means administrators are asking faculty and staff to continually produce more with less, and students are working harder

[5] That the standard for non-inflationary grading is as high as 40 % "A"s shows exactly how absurd and meaningless grading has become.

and longer hours to pay for their education. This leaves us all with less time for reflection and less time to be in meaningful relationship and exchange with each other. Second, the framing of students as customers shifts the expectations for classroom interactions away from authentic expression and away from students taking responsibility for their learning; in privileged settings it increases students' sense of entitlement to high grades, to be given the answers and to be entertained.

The framings of diversity in higher education, mirroring those in corporate America, present obstacles to teaching for social justice. Avery Gordon (1995), for example, critiques framings of diversity that celebrate difference but do not address power and privilege. In the sciences and engineering, diversity is framed in individual terms – something that greater self-efficacy, or more tutoring, or more mentoring, can address. Typically these "problems" are dealt with outside the classroom through minority in engineering or women in engineering programs (Riley et al. 2013).

In engineering classrooms, it is typical to avoid all mentions of diversity in any form; we do not even perform celebrations of diversity because we are busy pretending that the field is objective, and people's backgrounds and identities do not matter. With these commitments at stake, to break the silence in the classroom around difference, power, and privilege is to make a radical epistemological break. Belief in a colorblind meritocracy prohibits considering the possibility that by not broaching the subject, we are in fact teaching privilege. It is inconceivable that this "objective" version of engineering where people leave their identities at the door is instituting a straight white middleclass male standard, and erasing all other expressions of self (Downey and Lucena 1997). And so, as engineering undergraduates go on to earn their doctorates and join the professoriate, the system perpetuates itself.

The engineering major is structured in ways that emphasize the technical, despite a stated goal of integration with the liberal arts (see Cech's chapter in this volume (Chap. 4) for a critique of attempts to depoliticize engineering by artificially creating a "technical" and "non-technical" curriculum). At Smith we assembled a curriculum that we felt we could teach based on our disciplinary educations, based on available textbooks – a "greatest hits" of engineering that drew something from chemical, civil, mechanical and electrical – a circuits class, solids and fluids, mass and energy balances, etc. Then we put design in the intro and capstone courses. Ethics, social context and communication skills and teamwork are all relegated to "across the curriculum" approaches. On the one hand, it's clear that ethics (as well as communication, design, and social analysis) clearly belong "across-the-curriculum" rather than isolated into one course, because students need to see faculty model the centrality of these elements in the core work of engineering. But then why don't we call our approach to teaching technical analysis, problem solving, and lab work "across the curriculum"? The designation implies a second-class status, and it requires commitment and participation of faculty, which is difficult to maintain over time, even with good intentions.

Academic departments and disciplines encourage students to compartmentalize their knowledge and abilities. I don't think students balk at writing papers for their humanities courses, but they see it as a major affront in thermodynamics. Students have learned a sense of ordering of knowledge, what skills belong where – and they learn it from the institution itself.

Tenure is a central driving force of faculty priorities in academic institutions, exerting pressure toward conformity with the status quo. In my case, tenure pressures were both an obstacle and an unwitting facilitator of my work. On the one hand, senior colleagues were clear that my work integrating ethnography and risk assessment (Riley et al. 2006b) was not technical enough. I knew I was expected to apply for an NSF CAREER award, but conversations with program officers across the two relevant divisions (Social, Behavioral, & Economic Sciences and Environmental Engineering) revealed that a collaborative proposal across the two was a non-starter. At the suggestion of a mentor, and to please senior faculty, I applied for a CAREER award in another area – engineering education. Had my proposal been rejected, it would have been the death knell for my tenure case. But because I received the CAREER award, my pursuit of critical pedagogies was vindicated. Similarly, student unrest with my pedagogies could have killed my prospects, but because I was studying my own implementation of these pedagogies, I was able to collect strong evidence for its effectiveness as well as theorize student resistance to it.

The CAREER award has in turn created countless opportunities, including the thermodynamics book project and opportunities to participate on national advisory committees and collaborate with other scholars. It is hard to overestimate the impact of this award; it raised the profile of my work, and at the same time brought attention to the engineering and social justice movement. This attention attracted kindred spirits to the work, but also carried risks of co-optation.

ABET in some ways has provided a justification for my work, but it is also the source of several hindrances. Why we need ABET accreditation in the first place is based in Smith’s social location in engineering circles; as a liberal arts college, it is suspect. As a women’s college, it is even more so. It only raises more questions that, due to both size and a desire to be integrative across disciplines, we have an engineering science program. What is that? Is our engineering education rigorous? Is it *really* engineering? Being accredited, and being able to explain that engineering science is an accredited category in engineering, is essential for our reputation. And we have “bought in” to the notion that we need affirmation from this system with its bizarre hierarchies of gender, institution type, discipline, etc.

As Serron and Silbey (2009) observed of Smith and other engineering programs, ABET limits our everyday functioning. As a school that sends students abroad, we must certify that students are acquiring equivalent educations elsewhere to those offered on site. This restrains our own course offerings; the more similar they are to standard courses, the more easily our students will be able to study abroad. Our syllabus goals have to ultimately be matched with ABET outcomes; it is far less work if they match very closely, or exactly.

ABET’s reliance on outcomes based education is fundamentally flawed (Riley 2012; Slaton 2012). Classroom process is ignored entirely; we care only about what students can do at the end. Its corporate jargon and reliance on mass production ideas from Ford and Taylor, and its reliance on empirical evidence forge a good fit with engineering and with current trends in academia, but work directly against social justice goals (Berlach 2004). Ultimately, outcomes-based education works to prepare students for the social order of the status quo (Capper and Jamison 1993) and, in ABET's case, meeting the needs and requirements of industry and government. Engineering, like other professional degree programs, prioritizes employability of graduates and reinforces careerist impulses of students. Even liberal arts college students, faced with capitalism's realities, value credentialing over other aspects of a liberal education such as ethical development or civic engagement (Humphreys and Davenport 2005).

ABET points to a larger obstacle relating to national priorities and the ways in which educational systems serve the goals of the state (Gramsci 2001) particularly when it comes to the education of engineers. Teaching engineering with critical pedagogies does not change the fact that students' job opportunities will be largely with the defense industry, and/or with corporate interests. In a dialogue between Ira Shor and Paulo Freire (1987), the two discussed the propensity of students to be driven by their need for gainful employment, and Freire argued that it is essential to help students prepare for the world as it is, even as it is essential to help students question the status quo and struggle for a more just world. This is, Freire and Shor note, a contradiction that challenges students at the level of epistemology, and bears close relation to teaching material alongside its critique. Thus, engineering education is a rich site for enacting these pedagogies and initiating these kinds of dialogues with students.

3.4.2 Students and Faculty

Students' resistance to critical pedagogies is a product of their social location in academic settings. They are, in traditional classrooms, expected to obey their teachers. Critical pedagogy invites students to claim power in the classroom, which leads to a variety of forms of resistance to classroom power structures as well as institutional or public power structures. I have written elsewhere about student resistance (Riley and Claris 2009) and described several different manifestations and how they can be a productive source for student learning and growth. Students can be allies, resisting institutional power, or they can be local resisters of the classroom changes, invoking institutional power in favor of traditional education. A classroom interaction several years ago illustrates the latter dynamic: just before Thanksgiving, when stress levels were peaking, a student held up a graded essay in one hand and a problem set in the other and proclaimed "THIS [the essay] isn't thermodynamics," then held up the problem set and said emphatically "THIS is thermodynamics!" (Riley and Claris 2006). On the one hand, the student had come into her own power enough to proclaim what should and should not be in a thermodynamics course; unfortunately she had drawn the same conclusion as engineering traditionalists.

Some of my students resist the emphasis in my courses on non-technical topics – in particular they resist writing and ethics analyses. They see these as outside engineering, reiterating the classic split in the academy that is reinforced by institutional structures and by the day to day practices in other classrooms. They wrongly assume that because I integrate these subjects with technical aspects of thermodynamics, I must hate the technical material (see Cech this volume (Chap. 4) for further analysis of this technical vs. non-technical split).

They resist the extra work involved in taking responsibility for their own learning. Why wouldn't they? It is in their best interest to do so, especially with the pressures they experience in their overall workload. Fielding student questions and asking peers to discuss answers to them is interpreted as the professor not knowing the material. Holding students accountable for their responsibilities, even when done in gentle and supportive ways, is uncomfortable and difficult. With structures in place like grading and teaching evaluations, which set up an adversarial tit-for-tat, it is an uphill battle to maintain productive and positive learning relationships.

Among the faculty I have mostly enjoyed support and encouragement, or at least a hands-off approach to my classroom. I owe a huge debt to faculty in the social sciences and humanities who have collaborated with me or simply shared a coffee to discuss pedagogy. Still, many colleagues across the sciences have epistemic resistance to some of what I am doing in my classes and would view it as not belonging in engineering. In their own courses they clearly place more emphasis on the technical; even when they value the incorporation of non-technical material, they do this in a more limited way. This contributes to the struggle I experience in my classes.

3.5 How I Got Away with It (So Far)

Not every struggle for justice is successful, and even successful social justice movements have to contend with new and recurring forms of injustice well into the future. At the same time, each act of resistance has a local impact and carries its own significance in contributing to the cause in ways we cannot always know. By acknowledging the factors and forces that have facilitated my teaching in ways that I hope contribute toward social justice, perhaps I can identify successful strategies that others might use.

First, I came to teach in a new program without an entrenched faculty already invested in doing engineering education a certain way. While there are certainly differences among our faculty, these are small relative to the chasms of difference that I imagine exist between me and my own undergraduate professors. The vision for the program was to embed engineering in a liberal arts context, and we were free to incorporate elements from other disciplines into engineering. We chose an "engineering science" curriculum, itself interdisciplinary, which freed us from many of the curricular expectations we had learned in our disciplines and that we might have been otherwise obligated to impose on the new program. Founding the program after ABET 2000 meant that we worked from a list of outcomes, half of which were non-technical in nature. For us, it reinforced our liberal arts commitments and challenged us to fulfill these outcomes with a liberal arts depth perhaps not available in other institutions.

I took this opportunity very seriously and currently sit on program committees and teach cross-listed courses for both Ethics and the Study of Women and Gender. I have taught two courses collaboratively with community-based learning projects in the Study of Women and Gender, and one with our Design Clinic Director and a faculty member in Economics and Latin American Studies. I have found a great number of pedagogical and curricular resources though these exchanges that would probably not be as accessible in a larger institution where there are separate pedagogical and curricular conversations in engineering. Structural resources – for example, funds to develop non-Western themes in the curriculum, speakers like bell hooks visiting campus, and the ability to audit two courses in Spanish and one in History – have contributed to my professional development and facilitated some of the transformations I've made in my courses. The fact that our institution has a day for poetry, and a day to celebrate the first African-American student at Smith gives me license to talk about difference, power and privilege, or to utilize ways of knowing not traditionally accessed in engineering classes. So in many ways both my peers and my institution have been supportive of my efforts. At the same time, my peers in the sciences and engineering do not take this same license, and I am the only one I know of who extensively engages conversations of difference, power, and privilege in my technical courses or who teaches material alongside its critique. They tolerate me, but do not join me, and at times this kind of tolerance wears thin.

Having supportive networks outside my institution has been essential to this work. It started after all from conversations with a sociologist on another campus. It has been sustained by relationships with colleagues on campus and at other institutions, most of whom I have met through the Engineering, Social Justice, and Peace (ESJP) Network and through the Liberal Education/Engineering and Society (LEES) Division of ASEE. LEES has been a particularly supportive environment for exploring social justice topics in unconventional (for ASEE) formats. The division hosted the first paper on the experiences of queer students in engineering (Cech and Waidzunas 2009), and several special sessions on social justice, including "Engineering for Social Justice" (2006), "Tree Huggers, Diggers, and Queers, Oh My!" (2009), "Normative Commitments and Public Engagement in Engineering (2010)," "Myths about Gender and Race" (2011), and "Ethical Perspectives on the Grand Challenges of Engineering" (2011).

Conventional forms of prestige have given me some authority and privilege that I seek to put on the line to push justice further where I can. I am an Engineering professor, not any kind of hybrid. I teach a core course, thermodynamics, unassailable in rigor. If I taught intro courses only, or social science-y courses only, or design, I would not be afforded the same respect, nor receive the same amount of blowback. My NSF CAREER award has legitimated my work and created access to collaborators, allies, and resources to further the work. While I engaged this work before tenure, having tenure now affords a certain amount of security. Getting tenure itself was a product of all of the forms of support I have mentioned here. Other types of recognition and further advancement remain an open question; students' divided response to my teaching methods or the unconventional nature of my scholarship (this piece a case in point) may yet exact a heavy price.

In my activist life I have always known when I made an impact by the size of the reaction from the opposition; I can't shake the feeling that either I got away with something here, or I have not done nearly enough. Will it all catch up to me? Or is it that academic culture, with its arcane tenure system, fosters an over-cautiousness in which we are our own worst censors? Knowing what one can get away with, and what one is willing to risk – Student evaluations? Respect of one's peers? Backlash from a chair or dean? Staying at a particular institution? Staying in academia? – is essential for social justice work.

Other institutions are obviously different from mine, with different forms of constraint but also different points of freedom and opportunities for resistance. For example, outside of meeting set curricular goals, there may be less oversight or policing of teaching at larger institutions than in mine where students speak frequently with my colleagues about what goes on in my classroom. There may be room for a specific elective course on engineering and social justice at a large institution, while at Smith a small number of electives have to serve our entire engineering student body, driving a more general course on science, technology, and ethics that can dilute focus on social justice (Kabo 2010). With a larger faculty there may be more opportunity to find kindred spirits; coupled with a more generous team teaching policy, these connections might be extraordinarily fruitful sites for teaching social justice in new and creative ways. Some institutions have greater support than mine for community-based research and community-based learning, which can be directed toward social justice ends. Many institutions have policies for tenure and promotion with greater checks on fairness and/or more opportunities for allies to advocate for individual candidates. The key is to find the places in each institution where one can resist effectively. While such acts rarely come without cost, as in other social justice movements there are infinite opportunities for inspired actions, and weighing the cost accurately (and matching it with what one is willing to risk) is part of the process of planning effective strategy.

3.6 Conclusion

Like many professors, I cherish deeply the continuing contact I have with my students. If they choose to share their struggles with me, I can see the ways they think critically and act reflectively in their lives. Many alumnae have worked as engineers for a few years and come to a place of searching for work that might address social justice goals. I have tried to facilitate connections among them in the hopes they might together be able to build something different in engineering. I believe their engineering education was radically different from my own, due not only to my efforts but also to those of my colleagues and so many faculty members who struggled before us toward a more socially just education within and without engineering. This sustains me.

It is lonely doing this work. While a collection like this one reveals a community of like-minded colleagues working toward some common goals, this community is still forming and growing, and is so dispersed that it does not exist for many of us in our day-to-day activities. I am extremely fortunate to have many allies on my campus, even in my department, and yet I still feel alienated at times.

Struggling for social justice in unjust academic institutions, or in the unjust discipline of engineering, is not a futile effort; on the contrary it is exactly where we need to be. We need not, and must not, go it alone. Our struggles, whether we win or lose, create communities that sustain one another in the work, now, and long after we're gone.

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Part III
Conceptual Contributions to ESJ

Chapter 4
The (Mis)Framing of Social Justice: Why Ideologies of Depoliticization and Meritocracy Hinder Engineers' Ability to Think About Social Injustices

Erin A. Cech

Abstract Engineers will incorporate considerations of social justice issues into their work only to the extent that they see such issues as relevant to the practice of their profession. This chapter argues that two prominent ideologies within the culture of engineering—depoliticization and meritocracy—frame social justice issues in such a way that they seem irrelevant to engineering practice. Depoliticization is the belief that engineering is a "technical" space where "social" or "political" issues such as inequality are tangential to engineers' work. The meritocratic ideology—the belief that inequalities are the result of a properly-functioning social system that rewards the most talented and hard-working—legitimates social injustices and undermines the motivation to rectify such inequalities. These ideologies are built into engineering culture and are deeply embedded in the professional socialization of engineering students. I argue that it is not enough for engineering educators to introduce social justice topics into the classroom; they must also directly confront ideologies of meritocracy and depoliticization. In other words, cultural space must be made before students, faculty and practitioners can begin to think deeply about the role of their profession in the promotion of social justice.

Keywords Depoliticization • Meritocracy • Culture of engineering • Framing of social justice

4.1 Introduction

As part of the ethics course in my undergraduate engineering program, my classmates and I were required to prepare a presentation on an ethics topic that interested us. I decided to use my presentation to discuss Affirmative Action policies in engineering

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firms. I knew it would be a tough sell, but I believed in the importance of introducing inequality issues into class conversations about engineering ethics. Armed with statistics and arguments I learned in my social science courses, I described the structural roots and historical linage of gender, racial/ethnic, and class inequality and the reasons Affirmative Action policies were developed in the first place. Two thirds through my presentation, the classroom erupted into an unruly and increasingly angry debate about the very existence of inequality. My talk was abruptly derailed after one of my classmates scoffed: "poor people are only poor because they are lazy and stupid." The majority of the class laughed and nodded in agreement.

It was not until several years later that I began to understand that this event was not an isolated experience involving a classroom full of people with a particular disregard for social justice issues. This was a *framing* problem, one that is widespread in engineering education and the engineering profession more broadly. My discussion of social justice elicited a hostile response because it introduced a "social" issue into a context that is otherwise considered strictly "apolitical." As such, the issue was seen as irrelevant to that very context. To add to my crimes, I approached inequality in a way that is antithetical to engineering's dominant way of understanding achievement and failure. As I argue, this framing problem not only means that social justice issues are bracketed in traditional engineering education and practice, but also that changing engineering curriculum to include concerns of social justice will likely be met with complacency and, possibly, resistance.[1]

This chapter theorizes the cultural reasons why introducing social justice concerns into engineering contexts is such a tremendous challenge. Namely, that the professional culture of engineering frames social justice issues as, by definition, separate from traditional engineering concerns. I argue that two prominent cultural ideologies within engineering—depoliticization and meritocracy—frame issues of inequality and injustice as irrelevant to engineering practice. As I explain, these ideologies interlock to reinforce the (mis)framing of social justice issues in engineering. As a result of professional socialization experiences in engineering programs, during which students learn what it means to be a "good engineer," engineering students come to reproduce these ideologies and define social issues as simply unimportant to their own roles as engineers.

At the most basic level, engineering students and practitioners will only be motivated to consider social justice issues to the extent that they recognize such issues as relevant to engineering practice. I contend that only by directly confronting ideologies of depoliticization and meritocracy, thereby making *cultural space* for social justice concerns, can engineering education effectively promote such concerns among students.

I begin by describing the ideologies of depoliticization and meritocracy and their integration into engineering culture, and how these ideologies reinforce one another to frame social justice issues as culturally irrelevant to engineering practice. I end with a discussion of how engineering educators might break down these ideologies and reframe social justice issues as integral to engineering practice.

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[1] Schneider and Munakata Marr (Chap. 8, this volume) offer a useful "flexible" definition of working toward social justice as an "attempt to redress the unequal distribution of goods, rights, or opportunities, or to challenge policies or practices that exacerbate inequalities among groups of people" (p. 19).

4.2 Cultural Ideologies in Engineering

Engineering, like other professions, is not just a collection of knowledge, skills, and practices grouped into a set of jobs. Professions have rich and historically-rooted cultures that are built into and around their knowledge, skills, and practices. Professional cultures are the sets of beliefs, myths, and rituals that give meaning to the intellectual content and practices of a profession. Professional cultures serve several purposes in addition to giving meaning to professional work: they bind profession members together as a social group, provide the foundation of professional identities among group members, draw boundaries between profession members and "others," and they offer justifications for the privileged social status held by their members (Abbott 1988; Friedson 1971; Grusky 2005; Grusky and Sørensen 1998; Weeden and Grusky 2005).

Engineering, as a profession, has its own culture that is relatively autonomous from the larger societal culture and from other professional cultures (Abbott 1988; Bourdieu 1984). This culture is the foundation of everything from notions about engineers' "professionalism" to the social bonds that make "engineering jokes" humorous (Trice 1993). This culture extends far beyond specific engineering tasks (such as the value put on "elegant" coding solutions) and encompasses a rich set of beliefs about what it means to "be" an engineer. Boundary drawing procedures close engineering culture off from those who are uninitiated, and this culture often makes little sense to those outside the profession (Abbott 1988; Haas and Shaffir 1991). Although there are variations of engineering culture by geographic region and subfield, engineering culture is rich and enduring.[2]

An integral part of the culture of engineering is the promotion of particular ways of understanding society and engineers' roles and responsibilities therein. These specific *cultural ideologies* shape how engineers understand their own work, their responsibility to the broader society, and what counts as "engineering work" and what is superfluous to that work. Cultural ideologies provide frames through which profession members understand complex aspects of social life, both inside and outside the purview of their profession. Cultural ideologies can have wide-sweeping effects both on how the profession as a whole acts (for example, the National Academy of Engineering's choice of "Grand Challenges" priorities [http://www.engineeringchallenges.org/]) and on how individual engineers think about their work in relation to society.

Those who wish to participate in the engineering profession must not only learn the proper skills and competencies required of practice in the field, they must learn to "fit in" with the culture of engineering by adhering to these ideologies (Barley and Tolbert 1997; Dryburgh 1999). The most concentrated presentation of professional culture is through professional socialization—the training process by which students move from being neophytes to professionals (Becker et al. 1961; Schleef 2006). By taking classes, working in labs, engaging in design teams, and struggling through homework assignments, engineering students not only learn thermodynamics and circuits, they also learn to become a part of this culture. Students are introduced to

[2] Engineering cultures differ by national context, variation that is partly contingent on the origin of engineering as a profession in each country (Downey and Lucena 2004).

the norms, beliefs and ways of understanding the world common among their profession members. For example, they learn the difference between "white-hat hackers" and "black-hat hackers" and how to work together in design teams. They, in other words, *learn to become* engineers. In this way, the professional culture of engineering is perpetuated among the next generations of engineers. Socialization is also a broader process of learning—and learning to justify to oneself and to others—one's privileged status in the capitalist labor force (Becker et al. 1961).

Engineering students enter engineering programs as freshman with a myriad of beliefs about the social world. But, because cultural ideologies within engineering form the centerpieces of engineering culture and engineering identities, most neophytes adopt the cultural frames of engineering.

Although the majority of engineering students take on the prominent cultural ideologies of engineering as their own (Cech 2010), the absorption of these ideologies by everyone is not actually necessary to uphold them within the culture of engineering. As I will discuss, engineering students, faculty, and practitioners may be personally skeptical of the ideologies of depoliticization and meritocracy, and they may even see advancing social justice to be of central importance to their core values systems. They do not have to personally *agree* with these ideologies for them to be perpetuated; engineers must simply agree to "go along" with the culture of engineering and bracket social justice concerns from engineering contexts. Such pressures to go along are sizeable: those who do not may be ignored at best and sanctioned at worst. Thus, engineering students, faculty and practitioners who find social justice issues personally important but keep them off the table in engineering contexts so as not to "go against the grain" perpetuate this (mis)framing equally effectively as people who embrace these ideologies.

I argue that two particular ideologies within the culture of engineering frame social justice concerns as tangential and irrelevant to engineering practice. These ideologies—depoliticization and meritocracy—actually reinforce one another in engineering contexts and legitimate ignoring social justice issues altogether. As I will argue, simple "additive" pedagogies that sprinkle social justice issues throughout classrooms or lab environments will likely fail. Engineering educators must first deconstruct these ideologies before cultural space can be made for the serious consideration of social justice issues. I will next describe these ideologies, explain why they prevent social justice from having a central place in engineering education, and argue why engineering educators must first dismantle these ideologies and reframe social justice issues in order to make them more central to engineers' notions of what it means to be members of their profession.

4.3 Depoliticization of Engineering

The first important ideology within the culture of engineering is the notion that engineering is a purely "technical" domain, and thus asocial and apolitical. Because science and mathematics knowledge is understood to be the basis of engineering expertise, engineering work is assumed to be carried out objectively and without bias. Indeed, this is the foundation of logical positivism, the belief that science and engineering work can be separated from messy "social" concerns as long as proper scientific and engineering methods of inquiry and design are followed (Johnston et al. 1996; Klee 1997). As presumed "neutral" actors, engineers defer to the objectivity and value neutrality that are assumed to be part of these methods (Seron et al. 2011; Faulkner 2000).

However, as decades of Science and Technology Studies research has demonstrated, even the most seemingly objective and neutral realms of engineering practice and design have built into them social norms, culturally-informed judgments about what counts as "truth," and ideologically-infused processes of problem definition and solution (see e.g. Knorr-Cetina 1999; Latour and Woolgar 1986; Mackenzie 1990; Traweek 1988). Engineering work is necessarily heterogeneous and "technological" work can never be separated from its social or political influences (Faulkner 2009; Cech and Waidzunas 2011). Indeed, prioritizing certain "technical" features (faster, smaller, cheaper vs. quality or sustainability) over others is a social and political choice at its core. Thus, the notion that engineering work can somehow be separated from the social world is *itself* a cultural frame for understanding what engineering is.

Connected to the understanding that engineering work can be separated from the social is the ideological belief that it *should* be separated from the social. I call this the ideology of *depoliticization*—the belief that engineering work, by definition, should disconnect itself from social and cultural realms because such realms taint otherwise pure engineering design methodologies.

Through the frame of depoliticization, the political and social foundations of all engineering work are culturally invisible in the meaning systems surrounding that work. More importantly, the ideology of depoliticization means that aspects of social life that have to do with conflicting perspectives, cultural values, or inequality are cast as "political" and thus irrelevant—perhaps even dangerous—to "real" engineering work (Cech and Waidzunas 2011; Faulkner 2000; Florman 1994). As a result, these concerns are defined as illegitimate to engineers' day-to-day work by the very culture of the profession. Engineering's status as a profession depends on its relevance to society, and depoliticization allows engineers to carry on with their socially important work (e.g. food and medicine production) without having to grapple with the messiness that comes with actually engaging with questions of the effects of engineering work on society.

The ideology of depoliticization is deeply rooted in engineering. Early engineers sought to ground their new profession in math and science knowledge to increase engineering's status as a profession. Thus, early notions of engineering design drew from similar enlightenment notions about the potential for "purity" in scientific inquiry, isolated from religious, social, or political influence (Hughes 2005; Nye 1994). From the mid-nineteenth century on, a key facet of engineers' privileged status in society was their assumed ability to make decisions from purely technical considerations. Engineers and scientists were called upon in the 1920s to help instill technocratic decision-making procedures into public policymaking. Technocratic rule was supposed to diminish emotion, corruption and "politics" in public administration (Jordan 1994). While the technological skepticism of the 1950s–1970s challenged the notion that technocratic leadership was possible or desirable (Florman 1994; Nye 2006), the ideology of depoliticization remained essentially intact. Today, most engineers continue to conceptualize and portray their work as generally above any emotional, social or political messiness.

Depoliticization means that "social" issues, which encompass considerations of social justice and equity, are considered inappropriate within engineering contexts. Engineering students learn early through professional socialization that justice issues are "social" and "political" and thus irrelevant to serious classroom and study group conversations. For example, an engineering student at "Gold University," a research-intensive public university in the western US, noted:

> It's just a different way of communicating with engineers than with all the people that I tend to hang out with… You don't talk about your feelings, you don't talk about the world and what's happening in it…I wish there was more of that in school, more about the consequences of technology, the history…Really, we're just doing the technical stuff. (Becky; quote taken from Cech and Waidzunas 2011, p. 11).

Another student at Smith college, a women-only liberal arts college that recently launched an engineering program, shares Becky's recognition of the lack of exposure to social and political issues she receives in her engineering courses:

> I have recently noticed that I cannot keep up or contribute anything of value to conversations about politics or current events. I simply have no idea what is going on in the world right now. All through high school I loved having political debates with people, but I haven't been able to take a single class in public policy, government, or social science in college, which are the subjects that Smith is known for. Because I haven't taken any of these classes, I seem to have forgotten everything I ever knew about American government and the legal system. It's kind of embarrassing. And its not like you can have a dinner conversation about physics or calculus. No wonder engineers are stereotyped as being social awkward…In fact, I got so many awkward silences from telling people my real major that I started telling people that I was majoring in architecture. Trust me, architecture majors have much more interesting conversations that engineering majors. (Meredith, Smith student; taken from Seron et al. 2012, p. 31).

Both Becky and Meredith (pseudonyms) notice this depoliticization, but their recognition of—and concern over—depoliticization is the exception rather than the rule (Seron et al. 2011). The majority of students take on the dominant depoliticized worldview that is core to the professional culture into which they are being socialized. In a study of engineering students at several universities, I found that social justice concerns (e.g. "understanding the consequences of technology," "improving society," and "professional and ethical responsibilities") became less important to engineering students over the course of their undergraduate careers, and that the cultural ideologies promoted by their engineering programs had a direct influence on the decreased importance of social justice issues to students (Cech 2010).

The perpetuation of depoliticization in engineering—and the subsequent bracketing of social justice concerns—does not require that all engineers adhere to this ideology. Indeed, many engineering faculty, practitioners and students may believe social justice issues to be important to them personally. However, they must simply be complacent with the cultural norms that social justice concerns be "left at the door" of engineering contexts in order for depoliticization to be perpetuated.

In short, the ideology of depoliticization renders social justice considerations illegitimate in engineering contexts. As such, these topics are rarely discussed, and those who introduce them risk being ignored, criticized or sanctioned. But what happens if social justice issues do make it to the floors of engineering classrooms, labs and workplaces? I argue that a second ideology in engineering, the ideology of meritocracy, frames the very existence of social inequality as the result of just and fair processes, and thus simply not of concern to engineers.

4.4 The Ideology of Meritocracy

The ideology of meritocracy is, broadly, the belief that success in life is the result of individual talent, training, and motivation, and that those who lack such characteristics will naturally be less successful than others (Arrow et al. 2000; Cech and Blair-Loy 2010; Young 1994). The meritocratic ideology is deeply engrained in the popular belief in the "American Dream" (success comes to those who work hard and dream big) and is resonant in the popularity of stories about individuals who pull themselves up by their "bootstraps" (Hochschild 1995). The meritocratic ideology is not just a way of interpreting the outcomes of successful people, however. It is often deployed as an individual-level explanation for sweeping wealth, gender, and racial/ethnic inequalities in the U.S. It is "a theory of justice in which distribution of rewards is expected from the distribution of individual talents" (Brickman et al. 1981, p. 175). This ideology is also a *moral* judgment—meritocracy legitimates the unequal distribution of rewards as the outcome of morally acceptable and fair processes (Cech and Blair-Loy 2010; Lerner 1980).

The meritocratic ideology is the most prominent explanation of social inequalities in the U.S. (Kluegel and Smith 1986). Because discrimination based on religion, class, gender, age, etc. is formally illegal, most Americans believe that inequality of outcomes is based on fair mechanisms. This belief relies on several assumptions: (a) that the opportunity for personal achievement is widespread; (b) that individuals are personally responsible for their position in society, and (c) that the overall system of opportunities and rewards is equitable and fair (Major and Schmader 2001). But, of course, over a century of social science research has demonstrated that all three of these foundational assumptions are false: the opportunity for personal achievement is severely restricted by the quality of education one's family can afford, processes of discrimination prevent equal access to opportunities for women and minorities, and other structural and cultural processes sharply curtail opportunities for those who are not wealthy, heterosexual, white men (e.g. Bonilla-Silva 2003; Fischer et al. 1996; Kozol 1991; Lemann 1999; Padavic and Reskin 2002). Just as being born into poverty is not the fault of children of the poor, it is a logical fallacy to blame individuals for the structural and cultural constraints that limit the sorts of opportunities available to them.

It becomes difficult, therefore, for Americans to cognitively reconcile the structural reality of injustices with the belief that the social system is equitable and just. However, the very framing of inequalities as the result of individual outcomes resulting from a meritocratic system allows Americans to square the visible differences in opportunities and outcomes for women, racial/ethnic minorities, and the poor with the general societal belief in equality. If the system is seen as fair, social injustices arising from that system are seen as legitimate.

Because the meritocratic ideology is a widespread cultural belief, many college students likely believe in this ideology even before entering college (Jorgenson 2002).[3] Popular beliefs about the "liberalizing" effects of higher education assume that, as a result of being exposed to broad-based liberal education, college students are more likely than the general population to recognize the structural basis of social inequalities (Kane and Kyyro 2001). However, the empirical support for this assumption is mixed at best. In most cases, higher education (especially in science and engineering) simply endorses an emphasis on individualistic hard work as the basis of success, rather than exposing the cultural and structural bases of social inequalities (Jackman and Muha 1984; Kane 1995).

Importantly, certain professions are more likely than others to reinforce a belief in meritocracy (Cech and Blair-Loy 2010). Disciplinary differences in the promotion of the meritocratic ideology are largely due to the values within their professional cultures. Business schools, for example, promote a potent version of the meritocratic ideology, where success is in reach of anyone with sufficient personal drive and experience (Khurana 2007; Schleef 2006). Indeed, high-level women in science and engineering firms who attend business school are significantly more likely to give meritocratic explanations for gender inequality compared to women who took other educational paths (Cech and Blair-Loy 2010). This is in contrast to other academic disciplines (e.g. social sciences and humanities) that promote a multiplicity of explanations of inequality, or simply encourage critical thinking skills that question dominant frames for understanding injustice.

The meritocratic ideology is deeply engrained in the culture of engineering. To the extent scholars have been able to trace the history of the culture of engineering, this ideology has been central to the worldview promoted in engineering for at least a century (Hughes 2005; Nye 1994). The maverick view of engineering innovation (exemplified by Thomas Edison and Steve Jobs) promotes a romanticized notion of success where individual hard work, talent, and dedication can lead to pathbreaking engineering designs even out of home garages (Hughes 2005).

The meritocratic worldview is widespread among engineers working in both industry and academia (Cech and Blair-Loy 2010; Fox 2006; Rhoton 2011; Jorgenson 2002). It is also a central ideology in the professional socialization within engineering education (Dryburgh 1999; Seron et al. 2011). As students learn to become engineers, they adopt as their own the dominant worldviews of their future profession

[3] It is also possible that students who enter college believing in the meritocratic ideology are more likely to select into some majors (i.e. science and engineering) than others. This consideration is beyond the scope of this chapter, however.

(Becker et al. 1961; Dryburgh 1999). Thus, the socialization of engineering students often reorients or reinforces their framing of social inequalities as the result of fair, meritocratic processes. As an example of how the meritocratic ideology is deployed, an MIT engineering student rejects Affirmative Action procedures that promote gender equity in engineering because such policies are counter to her framing of success as the result of meritocratic outcomes:

> In my mind, a woman will succeed if she wants to succeed. Maybe that is an overly idealized thought, but I'm going to live by it. Should such a policy be introduced to work fields such that every workplace would be comprised of fifty percent females and fifty percent males? … In my own opinion, however, I think it isn't right…I feel that the best person should get the job, regardless. (M20; taken from Seron et al. 2011, p. 12).

Why is the meritocratic ideology such a compelling frame within the culture of engineering for understanding social injustice? For one, this frame denies the structural foundations of inequality—foundations that may include the work of engineers.[4] If inequality is the result of individual failings, then the profession of engineering neither plays any role in that inequality, nor has any responsibility to attempt to rectify it. Secondly, the meritocratic ideology frees engineers from the responsibility to design accessible or inexpensive products that alleviate social problems but may have little profit potential (e.g. slower, less expensive internet connections that would allow more people to access the internet).[5] Again, the popularity of this ideology within engineering is not the result of uncaring or naive individual engineers, but rather the outcome of a cultural frame that eliminates these social complexities from problem definition and solution.

4.5 Misframing Social Justice Issues

The cultural ideologies of depoliticization and meritocracy are not benign. They have important effects on social justice and equality outside *and* within the engineering profession because these ideologies frame the way engineers understand social justice issues in the context of their engineering work. With this framing, discussions of power, discrimination, and inequality are considered irrelevant. The relegation of these issues as "political" upholds the cultural perceptions of "'technical' aspects of engineering as objective and neutral (although they are no less prone to bias, no less steeped in culture and politics than social aspects)" (Cech and Waidzunas 2011, p. 11). Depoliticization prevents issues of social justice from

[4]In the 1920s, for example, Robert Moses and his engineers intentionally designed hundreds of New York City bridges too low for city busses (which were typically used by poor and African-American New Yorkers) to pass underneath. This effectively prevented these groups from accessing the Long Island beaches, maintaining the beaches as white, middle-class spaces (Winner 1980).

[5]This is in contrast other professions such as law, where a certain level of pro-bono work is encouraged or expected.

being brought to the discussion of engineering design and other professional practices. The meritocratic ideology, furthermore, frames social inequalities as the result of fair processes of social sorting, and, thus, not actually a cause for action.

Not only do the ideologies of depoliticization and meritocracy undermine social justice considerations independently, they also *reinforce* one another. Depoliticization means that issues of social justice are deemed irrelevant to engineering practice. Even if such social justice issues are introduced into engineering contexts, the primary explanatory framework of inequality in engineering—the meritocratic ideology—casts social injustices as the result of an equitable, properly-functioning system of rewards. For example, challenges to depoliticization via the introduction of social justice issues into professional conversations are likely to be met by arguments legitimating injustices on the basis of meritocratic processes. On the other hand, someone who wants to challenge the meritocratic ideology and discuss structural and cultural bases of social processes may be brushed off as being politically motivated.

There is, in other words, little cultural space in engineering for professionals, students, or faculty to reflect upon engineering's role in reinforcing or undermining social inequalities. Since those inequalities are framed as the result of individual failings, any sort of structural influence—especially any influence that may arise from the engineering profession itself—are rendered invisible. Nor is there much cultural space for engineers to think deeply about how they might use their specialized knowledge to solve problems that advance social justice.

Equally importantly, these ideological frames can actually help reproduce social inequalities *within* engineering. In a colleague's and my study of lesbian, gay and bisexual engineers, for example, discussion of LGBT equality was considered political and thus irrelevant. One student articulated the power involved in the silencing of discussions of equality in engineering:

> In my department, [the issue of sexual identity] is sort of invisible. I think most of them are straight dudes who don't really think about the existence of people who are not like them. I think they have so much privilege that they can't understand what it's like for people who don't have that privilege. And, they think [that] other people getting privilege is taking it away from them (Sara, engineering student; taken from Cech and Waidzunas 2011, p. 11).

Silencing discussions of advantage and disadvantage in engineering, while simultaneously attributing the success of white, wealthy, heterosexual men (success partly resulting from structural and cultural advantages) to their own hard work doubly disadvantages women and minority groups within the profession.

This framing has several implications for the introduction of social justice concerns into engineering education. First, these ideologies leave little cultural space for discussions of social justice in engineering classrooms. Engineering educators may deem such discussions as irrelevant to thermodynamics or circuits, and students, learning quickly the cultural values of their future profession, may be either hesitant to bring up social justice concerns out of fear they will be ignored or criticized by professors or classmates, or may themselves consider such issues to be irrelevant (see, e.g. Riley, Chap. 3, this volume). And, as made clear in my example at the beginning of this chapter, the meritocratic ideology can quickly shut down such concerns as non-issues.

But what about the non-engineering core courses engineering students are required to take? Might they be a pathway for introducing social justice concerns? Students in most engineering programs in the U.S. are required to take a set of core courses outside the area of their majors. Some programs have sought to increase students' exposure to non-engineering courses, even as tighter accreditation requirements make such curricular innovations difficult. These courses are believed to help engineers be more "well-rounded" in their perspectives, and to be able to engage in critical thinking about their engineering work (see, e.g. http://abet.org and NAE 2004). However, the ideologies of depoliticization and meritocracy mean that these exercises of critical thinking in humanities and social science courses are likely compartmentalized by students as extraneous to "real" engineering work. The consideration of social and political issues developed in these core courses are, in other words, largely "left at the door" of engineering classrooms and engineering workplaces.

Thus, most engineering students currently do not graduate with the cultural frameworks necessary to consider social justice issues relevant to their engineering practice. Even if they do desire to understand the implications of their future work (as some of the students I have quote here), the prominence of these ideologies prevents students from developing the intellectual and analytical tools necessary to think about their work in that way—they simply have very little practice doing so.

4.5.1 Non-dominant and Dominant Groups Adopt These Ideologies

These ideologies—especially the meritocratic ideology—serve the dominant and powerful—i.e. white, middle-class, heterosexual men. The meritocratic ideology is particularly compelling to the advantaged because it is "considerably more gratifying for dominant groups to see themselves as reasonable and enlightened benefactors of society rather than as the self-serving benefactors of a biased social system" (Jackman and Muha 1984, p. 759). Might disadvantaged groups in engineering challenge the meritocracy and depoliticization of engineering itself, and thus disrupt these ideologies within engineering culture?

It is often assumed that ideologies which benefit the powerful are only upheld by the powerful (Young 1994). However, meritocracy and depoliticization are often also upheld by those who are disadvantaged by them. "We are psychologically motivated to believe that our own social system is fair and legitimate," even if such system serves someone else's interests (Olson and Hafer 2001). Thus, within engineering, even disadvantaged groups (e.g. women, racial/ethnic minorities, LGBT individuals) may also adhere to the meritocratic ideology and depoliticization. Rhoton (2011), for example, found that women science and engineering faculty fiercely defended their belief that these disciplines are fair, unbiased and objective spaces (even in the face of clear examples of discrimination) and upheld the meritocratic ideology in the process. Similarly, my colleagues and I found that women engineering students, even when faced with examples of sexism and inequality in engineering, interpreted those events using the frame of the meritocratic ideology (Seron et al. 2011). Additionally, even if women and under-represented minorities personally reject the ideologies of depoliticization and meritocracy, they are often hesitant to introduce issues that run counter to these ideologies for fear of being marginalized or labeled a “whiner” (Dryburgh 1999; Seron et al. 2011; Rhoton 2011).

Thus, we cannot expect that disadvantaged group members within engineering have the resources or viewpoints from which to challenge these ideologies. Such expectations underestimate the power of the professional socialization process to inculcate neophytes into the worldview of the profession to which they aspire, and unnecessarily burden disadvantaged groups with the responsibility for questioning the dominant cultural ideologies of their profession. Challenging these ideologies must be the deliberate and systematic effort of engineering educators and profession leaders.

4.6 The Insufficiency of One Lecture or One Essay: The Task of Reframing

What can be done to instill in students a sense that social justice concerns are central to their work as engineers—and provide them with sufficient practice to develop the necessary “reflexes” for social justice considerations? An “additive” solution whereby social justice concerns are added on to the end of engineering courses in the form of an additional reading or tacked on to an existing curricula in the form of a single course on social justice concerns, is unlikely to be effective on their own. Even if social justice issues are included as “engineering” assignments or courses, the ideologies I discussed in this chapter, and their subsequent misframing of social justice issues, mean that such lessons will be understood by students as *supplemental* to their engineering training rather than as *fundamental*.

The only way social justice issues can become central to the way engineering students understand their work and their role as professionals in society is to make cultural space for such issues. And, the only way that such cultural space can be created is to deconstruct the very ideologies of meritocracy and depoliticization. Deconstructing ideologies means just that: actually engaging students in conversations about the fact that these are *ideologies*, and not accurate representations of the engineering profession or the social world. Such deconstruction requires that engineering students and professors alike develop reflexivity about the professional culture in which they are embedded and recognize that criticisms of the legitimacy of certain values and beliefs within a profession’s culture does not constitute an affront to the legitimacy of the profession itself. By decoupling these cultural values and beliefs from students’ and faculty’s identification with (and admiration for) their profession, dialog about problematic ideologies within that culture become possible without anyone becoming defensive or reactionary. Obviously, the first place to start is to explain that professions actually have their own cultures, which exist relatively autonomously from wider societal-level cultures and subcultures.

Depoliticization can be challenged by pointing out the clear social and political considerations that go into everyday design priorities. Bruno Latour (1992) gives a compelling example of how a moral belief (that people ought to wear seatbelts while driving) was actually designed *into* car doors with seatbelts that strap in drivers when the door is closed. The inherently political nature of engineering also becomes visible when discussing controversial engineering designs. It is hard to ignore the political and moral issues involved in engineering designs of, for example, the gas chambers in Holocaust concentration camps (BBC 2009, http://news.bbc.co.uk/2/hi/8224666.stm). From extreme examples such as this, students can extrapolate to understanding how all engineering design is infused with social and political considerations (Lynch and Kline 2000). After all, to ignore the existence of such political and social influence is to lack a complete understanding of the engineering design process itself (Latour 1999).

Regarding the meritocratic ideology, introductory social science textbooks are full of examples that illustrate and explain how social inequities are far more the result of structural processes of disadvantage than they are the result of individual failings.

But, as Leydens (Chap. 9, this volume) points out, "as faculty, most of us are woefully unprepared to engage and integrate social justice issues into our disciplines and classrooms" (p. 11). Engineering educators who feel ill-equipped to discuss these structural processes could invite social science professors to guest lecture or co-teach courses, who could, for example, provide information (e.g. statistics on or causes of particular forms of social injustice) which becomes the context in which engineering students discuss the connection between social justice and engineering design. Furthermore, Leydens (Chap. 9, this volume) and Schneider and Munakata Marr (Chap. 8, this volume) describe faculty workshops designed to encourage engineering faculty to think about how to integrate social justice concerns into their course content, and Leydens explains how workshop facilitators can work past participants' resistance with meaningful and respectful dialog. Finally, engineering faculty can engage students in the task of researching the social justice issues built into particular design activities. This not only shares the burden of the information-gathering required for meaningful engagement with social justice considerations, but also gives students much-need practice finding such information—a necessary skill if we expect them to engage with social justice considerations in their future engineering work.

Once the ideologies of meritocracy and depoliticization have been deconstructed, students must have practice filling in the cultural space provided for social justice concerns. Several other chapters in this volume provide useful tactics for facilitating this skill development. Breaking down these ideologies would be most successful if abstract discussions were paired with concrete design activities. Such activities could address a social justice problem that—itself—challenges the meritocratic ideology (such as poverty, hunger, domestic violence, and underfunded schools) and use design procedures that fold social and cultural considerations directly into the design process.

Ideally, in such activities, instructors would begin with a general overview of the social justice issue in question through lectures (possibly from colleagues who are invited to guest lecture), readings and through student-led discussions based on credible sources students found on their own. Then, teams of students would be asked to design an inexpensive product or process that helps address this social justice concern. Finally, if time allowed, students would build and test prototypes of their designs and explain how their engineering design addressed the social justice issue.

As one example, students might investigate the issue of homelessness. The curricular segment would begin by assigning research-based readings on homelessness (Jencks's *The Homeless* (1994), Liebow's *Tell Them Who I am*: *The Lives of Homeless Women* (1993), and Rossi's *Down and Out in America*: *The Origins of Homelessness* (1989) are compelling and accessible books).[6] The class would then discuss homelessness as an issue of social justice. In part 2, students would break into small groups and conduct their own literature search for research on homelessness in American—how many people does it affect? For how long? What are the most common paths in and out of homelessness?—and then each group would report back to the class on what they found.

In part 3, the groups would conceptualize and design portable, lightweight, inexpensive, collapsible individual shelters that would provide homeless individuals with shelter and safety. Then, students would prototype their shelters and demonstrate them to the class. In part 4, time and administrative approval permitting, students would actually take turns trying out their shelters by sleeping on campus grounds overnight (ideally outside). This trial could be paired with a consciousness-raising campaign about homelessness in the local area. (See Hattery's article (2003) for an excellent discussion of instituting a similar "shantytown" activity.)

The very premise of this activity challenges the ideologies of meritocracy and depoliticization: students are required to confront the realities of an unfair system of rewards, to think about social justice issues through the eyes of the disadvantaged, and to fold those very concerns right into their designs. In the exercise, the success of the designs depends on the students' ability to understand the complex socio-cultural factors that go into the problem the design seeks to alleviate.

Students' ability to analyze how their engineering work is connected to social justice concerns takes practice, just like the development of any other intellectual skill. One lecture or one essay on "engineering and social justice" is not enough.

4.7 Conclusion

The purpose of this chapter was to explain how the culture of engineering hinders engineers' ability to see social justice concerns as relevant to their professional work. I explained that engineering has its own professional culture, complete with

[6]The National Coalition for the Homeless provides easily-accessible fact sheets on the prevalence and causes of homelessness in the United States (www.nationalhomeless.org)

cultural ideologies that frame how engineers see the social world and understand their roles and responsibilities therein. I argued that two prominent ideologies within the culture of engineering frame social justice issues as irrelevant to everyday engineering contexts. Depoliticization is the belief that engineering is a fundamentally asocial and apolitical space, and any discussion of social or political issues such as justice are out of place in that space. If social justice issues are introduced into engineering contexts, the meritocratic ideology frames unequal opportunities and outcomes as the result of a fair and properly-functioning system of rewards and thus not worth much attention from the engineering profession.

This misframing shields engineers from difficult considerations of how the profession's products might help reproduce social injustices and excuses them from the responsibilities for designing accessible, equity-promoting technologies that might not be profitable. The ideologies of depoliticization and meritocracy also reproduce inequalities for under-represented minorities within the profession by silencing serious discussions of power, privilege and voice with the profession's boundaries.

I argued that one way cultural space can be made for discussions of social justice concerns is if these ideologies are deliberately deconstructed. Engineering education provides the ideal site for this deconstruction, as it is the time in which neophytes are first introduced to the culture of engineering.

This deconstruction is not impossible—as is evident from the recent rise of "green" engineering (alternative fuels, sustainable building materials, etc.) as a legitimate and popular design approach (e.g. NAE's "Grand Challenge" of making solar energy economical). Only a few decades ago, designing with environmental impact in mind would have been framed as political and, thus, in contradiction to the ideology of depoliticization. This suggests that the culture of engineering, and the ideologies therein, are not intractable. The popularity of the "Engineers Without Boarders" organizations on hundreds of college campuses (http://www.ewb-usa.org/) suggests that many engineering students are hungry to explore how their professional roles might advance social justice. Only when cultural space is made for such issues can engineering educators, students and practitioners actually be able to seriously consider social justice issues a central part of their responsibilities as professionals.

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Chapter 5
What Can Buddhism Offer to a Socially Just Engineering Education?

Marisol Mercado Santiago

Abstract Buddhism is a tradition whose tenets, practices and rituals are regarded by some as a philosophy and others as a religion. At the heart of one of the main Buddhist schools, the *Mahāyāna*, is the practice (or cultivation) of the virtues of the Bodhisattva, also known as the "six *pāramitās.*" This chapter presents an introduction to the practice of the virtues of the *Bodhisattva* and a leadership model based on Buddhism. It demonstrates how the practice of the virtues in the leadership model can be interpreted as a framework to help engineering students and educators develop leadership and skills to support social justice. The chapter draws from previous work on the intersection of Buddhism, leadership, and culturally responsive education. The framework is connected to social justice through examples relevant to engineering practice and education. The goal of this chapter is to motivate engineering educators, who are interested in Buddhism and social justice, to connect their engineering knowledge with Buddhist studies (or socially engaged Buddhism) in socially just engineering education. In addition, it might open a way for those who are interested in integrating other philosophies in their engineering education efforts, such as Native American educators who wish to integrate Native American philosophies in engineering education.

Keywords Buddhism and design • Buddhism and engineering • Buddhism and social justice • Buddhist engineers

5.1 Introduction

My interest in engineering education stems from a long-time interest in helping communities in resource-poor countries to improve their quality of life. Some time

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ago, I became acquainted with Buddhism, and by extension, to the situation of Tibetan people in exile. Observing their plight and desiring to support their achievements, I decided to focus my efforts into understanding their beliefs, values and culture. Because Tibetan culture and Buddhism are intertwined, it became necessary for me to become versed in their religion and in their views on education, leadership, and problem-solving approaches.

Buddhism in general and Tibetan Buddhism in particular are rooted in morality. The ideal is to live a life that is in full accord with the highest moral ideals, as understood by Buddhists. These moral ideals are regarded as virtues to be developed through constant practice, striving to apply them to daily life situations on a consistent basis. The idea is to become better human beings and actualize our highest potential as enlightened beings.

Currently, I am working on my doctoral degree. As part of my dissertation, I am working with a group of the Tibetan Buddhist community in exile to develop an "Introduction to Engineering" course through a culturally responsive approach. In this chapter, I will describe my initial work to connect Buddhism with engineering education; aimed for Buddhist communities or schools in resource-poor countries or disadvantaged contexts. Part of the content of this chapter will be used to write a course project that pre-college students will do as part of the course. I will develop and teach the course in a Tibetan Buddhist community in exile in India. The teaching and research of the course is part of my doctoral dissertation.

I hope that this chapter encourages other people interested in connecting Buddhist studies with socially just engineering education or practice.

5.2 The Practice of the Six Virtues of the Bodhisattva Path

In the *Mahāyāna* Buddhist tradition (one of the three main schools of Buddhism), the way of the *Bodhisattva* is a central practice, attitude, or internal state of being. Six virtues (also known as "the six *pāramitās*") have been identified in this tradition. The six virtues are interrelated because each one influences or supports the others. They are: generosity, ethics, patience, joyful effort (perseverance), mindfulness,[1] and wisdom. See Fig. 5.1 for a visualization.

By practicing *generosity* without seeking rewards, we set a "ground" to cultivate ethics and the rest of the virtues. By practicing *ethics,* we set up a "platform" to develop tolerance (*patience*). The practice of ethics will also prevent to harm others with our body, speech and mind, the three elements of the individual that the Buddhist path seeks to refine and transform. On the base of this "platform," we strengthen our minds through *perseverance* to pursue the activities that benefit others. By meditating and practicing *mindfulness*, we set "pillars" to the highest

[1] A commentator pointed out that some Buddhist scholars do not use "mindfulness" with "concentration" interchangeably. In their view, mindfulness is an essential mental factor required for concentration and the terms are not used interchangeably. For the purpose of facilitating the discussion in the context of engineering education, I am using "mindfulness" to refer to this virtue.

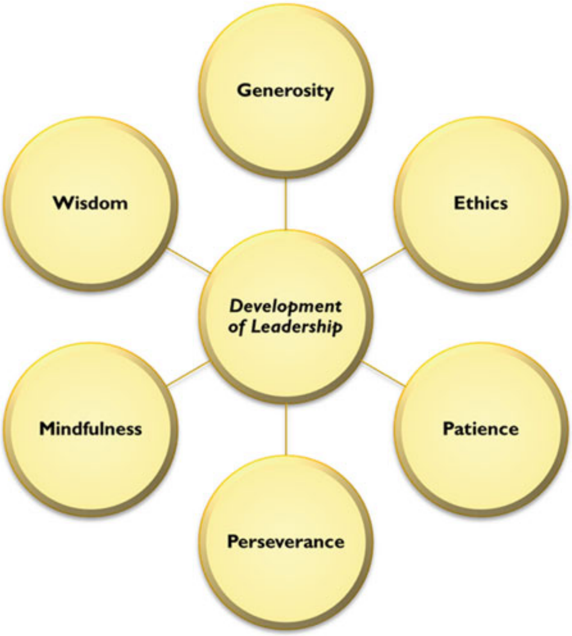

Fig. 5.1 The six virtues that support the development of leadership

attainment that will be *wisdom*. We can visualize the previous summary of the six virtues as a house built on the ground of generosity and with the foundations of ethics, patience, and perseverance. See Fig. 5.2.

The training of single-pointed concentration supports a calm state of mind through which we interact with others in order to benefit them (Thich Nhat Hanh 1998). It is important to note that when I speak of "the practice of" X virtue, I am referring to any life circumstance where one is aware that one is practicing the virtue as part of one's path to serve others. An example relevant to engineering education could be when an engineering teacher is trying to help a student understand an engineering topic, especially in any of the following contexts: the student may not be proficient in one's teaching language, may come from a different socio-economic background than most traditional engineering students, or may be struggling with a disability. In these cases, it is not sufficient for the teacher to be just an expert in engineering. The practice of the virtues contributes to the human dimension of engineering education: a sense of *generosity* is part of the mission of a teacher, *ethics* help us to interact respectfully with the student, *patience* help us exercise tolerance, *perseverance* remind us not to surrender our efforts to help the student, *mindfulness* makes us more sensitive to the situation, and *wisdom* about the student's situation help us support better his or her learning process.[2]

[2]Engineering studies scholar Lisa McLoughlin (2012) argued that patience is necessary in the process of recruiting and retaining students from low socioeconomic classes, such as transfers from community colleges, because their life circumstances may mismatch with the way that engineering education was structured around more traditional students from privileged backgrounds.

Fig. 5.2 Visualization of the practice of the six virtues in the form of a structure

5.2.1 Generosity

There are many ways to practice generosity according to the person's character and circumstances. We can practice giving material things, beneficial actions, and in the case of ordained nuns and monks they practice generosity by imparting *Dharma*. Dharma in this context means the teachings of the Buddha. For lay people (or non-Buddhists), teaching engineering (and other field of studies) is considered under this model a practice of generosity. In general, anything that one teaches to others through one's actions of body, speech, and mind with the pure motivation to benefit others is part of the practice of giving. It is "[e]ncouraging others to live in ethics, to practice generosity, to be patient, and to persevere in virtuous activities" (Rinpoche 2003 p. 362). Generosity is also regarded as a "tool" to weaken greed, one of the three poisons of the mind according to Buddhism. It is important to note that under Buddhist philosophy there is a belief that all phenomena and actions are interrelated, meaning that one's own actions may foster benefits not just to oneself but to others and society as well. Thus, generosity creates positive effects not just for the person who will receive one's "gift," but also for other people as well.

Engineering practice is in essence a collaborative process. To be effective, one needs to build relations of trust and respect with one's team members. Generosity in engineering education could be encouraged, for example, by teaching students to understand, value and respect the opinion, knowledge, and effort of other team members, no matter their gender, sexual orientation, socio-economic status or ethnic identities, and to treat them with support and respect regardless of disagreements. In engineering practice, examples of generosity can be found in the design a software for the needs of peoples with disabilities where engineers would have to patiently listen to the struggles that these individuals encounter, learn to see them as humans (not as clients), and respect them in spite of the difficulties that disability brings to orderly and linear models of design.[3] Here we can see that *social justice in engineering* is intertwined with the virtue of generosity, when we take into consideration the particular context and history of the people who have indicated the need of engineering support.

5.2.2 Ethics

From a Buddhist perspective, the practice of ethics is seen as a gift that one gives to others because it minimizes those actions that arise from thoughts and mental attitudes that lead to more suffering (e.g., social injustices) in the world. It has been argued that Buddhist ethics resemble what is known as *virtue ethics* in Western thought (Keown 2005). The concept of *ethics* in this case refers more to the Buddhist precepts for lay people[4] or "moral codes." Recall that in Buddhism the interconnection of beings is a central concept. Thus, following an ethical conduct is expected to have an effect beyond the ones that are directly affected by one's actions. Other way to see Buddhist ethics is that they involve (a) undertaking virtuous activities, (b) abstaining from activities that harm, and (c) undertaking activities that benefit others. It would be quite impossible to not harm *all* sentient beings, especially if one considers microscopic life forms or indirect harm. Rather, one must abandon the *intention* to do harm to the greatest possible extent (Rinpoche 2003).

Under this view of ethics, we are making the effort to prevent more harm to the environment and sentient beings through our engineering practice. This intention to not create more harm or suffering in the world can be interpreted as a way to support *social justice through engineering*. Buddhist ethics in engineering becomes a way to honor and respect all sentient beings; thus, challenging engineers to view, for example, a landscape not in terms of inputs and outputs, but as a place where all sentient beings, from microbes to humans, are interrelated and where this interrelationship should be respected. Beyond codes of professional ethics that many engineers tend to follow, but which do not include provisions for social justice, following a code of Buddhist ethics and inner reflections about one's actions as an engineer could be a more comprehensive frame of reference to help oneself be a more socially just engineer or engineering educator.

[3]For example, see the work of Tetra Society: http://www.tetrasociety.org

[4]There are five precepts for lay people: not to kill, not to steal, not to lie, abstain from sexual misconduct (adultery), and abstain from taking intoxicants It is an individual decision which ones to take and when to take them. The main purpose of observing these precepts is to avoid harming others.

5.2.3 Patience

The practice of patience seeks to help the person to understand that the happiness and peace of mind of one person depends upon the other and vice versa. Patience is closely associated to the principle of *dependent origination*: all phenomena arise not just because of one cause, but a collection of causes. In addition, patience is viewed as a "tool" to help overcome hatred, one of the three poisons of the mind according to Buddhism (Rinpoche 2003).

From a Buddhist perspective, patience encompasses forbearance, forgiveness, and tolerance (Soni and Bhikkhu Khantipalo 2010). It is interrelated with the other virtues (as are the rest). For example, one needs wisdom to comprehend that the causes of our actions towards others may have roots in ignorance and mental attitudes (Mitchell 2008). Patience is the optimal reaction when things do not go our way, since it will give us the awareness to stay focused on helping the engineering student when he or she does not grasp the concepts that we are trying to teach, as opposed to frustration and anger which will probable deter our students from learning. Anger can be further exacerbated by our pre-existing biases toward others, which may result in more suffering and injustices, as we might deter our students from learning and in doing so take opportunities away from them.[5] Patience, thus, becomes an essential practice for the socially just engineering students and the educator.

In engineering practice, approaching design problems with patience is important to reach our goals. Patience works in conjunction with perseverance. Even though the financial bottom line might challenge engineers to speed their work to save time and money, reminding our engineering students to practice patience and perseverance through an engineering project will help them overcome barriers that they might see impossible to solve, especially when working in critical projects with people with whom they need to develop trust and understanding. These projects take time, patience and perseverance. Many "barriers" in engineering projects, particularly those related to vulnerable populations that depend on the natural resources that will be altered by the engineers' work such as the construction of a dam, or energy plants, or development projects, might be negotiated with patience if more time is spent listening, observing and waiting for others to come to an agreement. Sooner or later, the future engineering student will face these situations, and in those cases, technical knowledge alone will not be sufficient to make agreements with the local populations. We can encourage engineering students to explore patience and other virtues when facing similar difficult challenges. This may help them see that engineering practice is not

[5] Anger could be a starting point for social justice, if we transform it into social action. The key idea behind avoiding anger is that we should not let anger consume us: it must not become self-destructive; it must not destroy others. If we start with anger but go beyond it to change the conditions of suffering, then, we transform that anger into social action motivated by compassion and wisdom.

comprised only of applied scientific knowledge, but also of other attitudes, behaviors, and ways of approaching the problem that may not be related to the traditional training as engineers.[6]

5.2.4 Perseverance

The word in Sanskrit is *vīrya*, which highlights a joyful quality to one's effort, as opposed to effort that feels like straining, toil or unpleasant. Here, one is enthusiastically exerting effort, like following or living one's passion. Joyful effort or perseverance is an enthusiastic joy that arises in our minds when we intend to do or engage in virtuous activities for the benefit of others. It has been argued that it is like a mental factor that fosters the actions of our body, speech, and mind to joyfully engage in any other virtuous practice; thus, it supports the other five practices. It is a zeal that keeps the person continuing a virtuous task even in adverse times (Rinpoche 2003); Mitchell (2008) argued that joyful effort or perseverance is a "sustained fervor that is necessary to maintain enthusiasm on the spiritual journey—which at times can seem long and arduous" (pp. 121–122).

From the Buddhist perspective, our joyful effort is intended primarily in striving to alleviate the suffering of beings. There is a world of suffering around us, and there is an urgency not to become lazy and to give the best of our efforts. Each sentient being has something unique to contribute to the world, and this practice helps us deliver our unique contributions.

In engineering practice, joyful effort helps to sustain enthusiasm in a project. Perseverance also is needed to reach consensus in a design team. I see joyful effort as part of the characteristics of a good engineer and leader. As engineering educators, we can become an inspiration for our students by showing, for example, perseverance when writing and editing a paper or a class lesson, making sure that every sentence is properly written and aimed at a target audience. Joyful effort is practiced by engineers around the world, including those who work for social justice, for example, those who work for the engineering and social justice projects of Waste for Life.[7] We can bring to classroom stories of engineers who have put into practice perseverance in their engineering practice and in their efforts for a more socially just society. One example could be the case of Steve Slaby, an engineering professor at

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[6]Baumann (2010) argued that practicing moderate patience can support innovation in engineering. The author used an agent-based simulation model to mimic the controlled environment of decision-making agents in firms (e.g., engineers in corporations). Tolerance of failures in exploring solutions and patience were closely aligned to innovation. Little patience was found beneficial in those cases were rapid prototyping is needed to develop insights quickly. Overly extreme levels of patience were found to be dysfunctional. A "middle way" patience (or "moderate patience" as the author defined), neither in one nor the other extreme, seemed to be beneficial to decision-makers in firms—such as engineers.

[7]For more information, see their Web site: http://wasteforlife.org

Princeton University who persevered in his efforts to get acceptance of a Technology and Society course, that discussed the implications of engineering and technology in society, and to foster an inclusive engineering education Wisnioski (in press). Another example is that of engineer Fred Cuny who persevered through adversity in the Bosnian war to provide the people of Sarajevo with an alternative source of potable water so they will not have to risk their lives to sniper fire (Pritchard 1998). In these examples, students can see how role models of perseverance lead to socially just engineering.

Ultimately, it is up to the student or engineer to derive passion from what he or she does. As Florman (1996) said:

> The engineer does not find existential pleasure [passion] by seeking it frontally. It comes to him gratuitously, seeping into him unawares. He does not arise in the morning and say, 'Today I shall find happiness.' Quite the contrary. He arises and says, 'Today I will do the work that needs to be done, the work for which I have been trained, the work which I want to do because in doing it I feel challenged and alive.' (p. 148)

This passion to do their service is what drives the engineers' perseverance (or joyful effort) and is what makes them feel "challenged and alive," as Florman (1996) p. 148 said.[8]

5.2.5 Mindfulness

In Sanskrit, the word is *dhyāna*, and it is usually translated as meditation. Thich Nhat Hanh (1998) stated that conducting one's daily life in mindfulness is a form of meditation and it supports concentration and understanding. The act of calming our body and emotions through mindful breathing, walking, sitting, and so on, may help us to live joyfully every moment and to connect ourselves with the rest of the sentient beings as well (Thich Nhat Hanh 1998).

Mindfulness helps us to generate a virtuous state of mind that is stable in concentration on an object or activity. The practice of concentration refers to a state of calmness, a state of insight. For instance, the act of mindful breathing is believed to remove distractions and its practice can also include daily errands and activities (Rinpoche 2003). In the field of engineering education, Catalano (2011) has been exploring how mindfulness in an engineering course (taught through

[8]I acknowledge that engineers face numerous challenges in their work. These challenges might be too tensed to practice virtues such as patience or perseverance. For example, we encounter challenges to meet deadlines, to make agreements with team members, to balance work and family life, and to have a work environment where team members can respect each other. In engineering education, we might need to deal with students' behavior problems in classrooms, schools with limited resources, and so on. I invite engineers interested in Buddhism to think about these internal issues of the engineering workforce and how these issues can be addressed to foster a just engineering.

contemplative pedagogy) can help undergraduate students learn engineering concepts in a fluid mechanics course. Contemplative practices are, for example, different forms of meditations, prayers, physical and artistic practices found in all religions and traditions, including Buddhism. Catalano (2011) has integrated contemplative practices in his bioengineering fluids course in the following ways: (a) 5 minutes meditation at the beginning of the class (different techniques were used, but he emphasized in *vipassana* or "insight meditation"), (b) 15 minutes of daily meditation outside of class, and (c) journaling and writing exercises that integrate reflections and comprehension of topics; such as laminar fluid mechanics, turbulent fluid mechanics, and how certain laws and equations have been instrumental in bioengineering (Catalano 2011).

Mindfulness is important because it allows us to be attentive to the present moment, where we have a maximum access to our inner resources and allows us to interact optimally with our environment. Neargarder (2009) explained how mindfulness (in her case practicing yoga) connects to engineering design:

> The similarities [between engineering and yoga] are not always as apparent, but they are there. You begin to notice them as your train your mind and body, working as an engineer to construct a stable structure with proper ventilation. And at the heart of yoga teaching are the concepts of *duhkha*, usually translated as meaning suffering, and *sukha*, usually translated as meaning ease. A literal translation of sukha brings us "good space", referring to the term used to describe the correct construction and alignment of a wagon wheel to its axis; a bad alignment creates duhkha, "bad space", or a ride filled with suffering; a correct alignment creates sukha, "good space", or a ride that is smooth. That is an engineering concept, right at the heart of yoga! So, the next time you practice, think like an engineer of your self: create a smooth ride (…).

The aim of this virtue is to promote a meditative state in which we do not react to the world from our habitual tendencies;[9] that could be driven by internalized biases that may create more social injustices in the world, even if we do not wish so. Rather, we are aware of what is going on internally and externally to fully exercise our power of choice and wisdom, and direct it toward social justice in our engineering and engineering education practice.

Design engineering involves creativity, collaboration, and awareness, among other aspects. The practice of mindfulness helps direct the mind's attention to the assigned tasks and other variables that may affect the project. The engineering educator can remind the students about the importance of mindfulness in design, listening to the team members' contributions for the benefit of the project and the people

[9] "Habitual tendencies" mean the predispositions that a person has due to his or her previous actions. In this case, I am referring to tendencies that are *detrimental* to the individual and others (e.g., greed). In Buddhism, there is a belief of the continuity of consciousness ("mindstream") even after death. One's actions make imprints in one's mindstream, forming predispositions to do equivalent actions in a future. This does not need to be permanent, thus, it is seen that effort placed in practicing actions that are opposite to the detrimental ones can gradually minimize the impact of them (e.g., practicing generosity to oppose greed).

who will make use of the design. Mindfulness of phenomena in nature may also facilitate engineering design activities based on *biomimicry*[10]: the application of biological designs found in nature to meet the needs of society (Gardner 2012).

Thich Nhat Hanh (2005) elaborated ideas on how to use mindfulness in public service, which can be also applicable in socially just engineering education. For example, the practice of mindfulness may transform moments of anger that one might feel while one is working as an engineering educator; thus, preventing actions that may cause suffering to others (even if we did not intend to do so). This might seem trivial, but imagine that your engineering student has an emotional disability or is a very sensitive person; one's anger may cause more stress in that person and consequently impede his or her learning process. Another example is when one's mind wanders to the past while an engineering student whom we are mentoring is in front of us speaking important ideas about his or her future projects. Thich Nhat Hanh (2005) speaks about the mindfulness of one's breathing as a tool to help oneself stay in the present moment and, thus, make an effort to *listen* and not just to *hear* a student. These examples, show us the relevance that the practice of this virtue has in our work as socially just engineering educators.

5.2.6 Wisdom

Buddhists speak of two types of wisdom: *conventional* and *ultimate*. Conventional wisdom refers to our everyday knowledge, from how to tie our shoes to how to be successful in our respective fields. Ultimate wisdom is the ability to understand the nature of reality, which in Buddhism is described as being "empty." In Buddhism, "emptiness" does not have the same meaning as in Western thought. It does not mean void, nihilism, or vacancy. Its meaning is closer to this statement: all phenomena in the world in reality lack independent conditions and are dependent on other causes and beings.

Wisdom also refers to a particular way of looking at things. The wisdom that Buddhists seek allows them to develop the presence of mind that the things of this world are ephemeral. Instead of pursuing titles and money, Buddhism invites us to seek a life of growth and giving (Mitchell 2008; Rinpoche 2003). To be wise, socially just engineering educators need to develop the presence of mind to notice the suffering that others experience and to seek ways to alleviate it using our minds, speech, and actions. It includes an awareness of the suffering experienced by people all around the world; for example, poverty and its possible consequences (e.g., sexual abuse, human trafficking, illnesses, and so on). If we overlook the core sufferings of the world around us, we overlook a way to develop *insights* about the interrelated *causes*, *conditions*, and *consequences* of those problems. Knowledge

[10]Important innovations in society have been accomplished through the contemplation of nature. For a list of examples, you can refer to http://www.asknature.org

about the layers that caused the conditions for suffering becomes a way for *wisdom* to develop and for *effort* (perseverance) to foster other conditions to effect change and transformation in society. In engineering, one of the closest mundane concepts to ultimate wisdom could be *systems thinking*. In order to think in systems, one might need a transformation of one's perspective of seeing phenomena in the world. It involves examining dynamics among the parts of a system that could be related to conflicts, tensions, and contradictions (Frank 2006). Thinking in terms of (a) system *emptiness*, (b) dependent arising, (c) lack of inherent existence, (d) interdependence, and (e) impermanence may help develop a systems thinking approach to design. Those five concepts are often used when Buddhist teachers speak of ultimate wisdom. For example, when an engineering student (or engineer) examines a systems problem, being mindful that each variable is *empty* (dependent upon other causes) may generate additional questions in his or her mind (e.g., what are the other causes that made up this problem? What other parts are involved?, and so on). In other words, engineering educators can remind students that nothing has an independent existence; therefore, we should also investigate what are those other causes, conditions, and effects of a system part to help develop the systems thinking in our engineering students.

In engineering practice, conventional wisdom can be translated as the lessons learnt from previous projects that failed or succeeded. Petroski (1992) viewed that engineering failures, even if they were disastrous, give lessons of design to engineers: "(…) the colossal disasters that do occur are ultimately failures of design, but the lessons learned from those disasters can do more to advance engineering knowledge than all the successful machines and structures in the world" (p. viii). Helping our engineering students to reflect about theirs and others' experiences in practice and team collaborations is also a way for them to develop wisdom that will later help them as engineers. Engineering students can also reflect on the impermanence in engineering practice; for example, previous designs may no longer fit with the new needs and they will need to be adjusted. This is not the ultimate wisdom that Buddhism speaks about, but it may lead the person to develop the inner insights that Buddhism seeks.

5.3 The Practice of the Six Virtues and Leadership Theory

The practice of the six virtues is closely aligned to the concept of the *servant leader* in leadership theory. In fact, Greenleaf in his own work mentioned that he was influenced by Herman Hesse's "Journey to the East" in developing the concept of the servant-leader. According to Greenleaf (2007), a leader is one who is servant *first*. In his model, a leader "begins with the natural feeling that one wants to serve, to serve *first*" (Greenleaf 2007 p. 412). Just like servant-leaders, those who do the effort to practice the six virtues (a) have a commitment to serve the needs of people first and (b) have begun in this path because of a "natural feeling" (Greenleaf 2007 p. 412). In Buddhism, this deeply-felt commitment is called *bodhicitta*. The term can be translated as the desire for enlightenment for the benefit of all sentient beings (Brassard 2000). Here "enlightenment" does not refer to the "Age of Enlightenment" as understood in Western society. In Buddhism, enlightenment could be both a final state of being and a process … or could it be neither? In reality, enlightenment cannot be defined (and I certainly do not know what it is!); however, the word "awakening" has been used by Buddhists to try to explain the concept of "enlightenment."

The arising of *bodhicitta* in oneself is the starting point of the *Bodhisattva* path. It is like the starting point to transform oneself as a socially just engineering educator.[11] This zeal to work for the benefit of all sentient beings (including one's engineering students) will be our central point from where we will operate as a socially just engineering educator.

5.4 Three-Level Model of Leadership Based on Buddhism[12]

Kemavuthanon and Duberley (2009) conducted a qualitative research in the Thai community organization "One tambon, one product" (OTOP) (a "tambon" is an administrative sub district in the Thai society). This project helps rural Thai people to become self-reliant, alleviate their poverty, increase job opportunities, reduce the depopulation in rural areas, and protect the environment, among other goals. Women outnumbered men in this project. The project involved both active leaders and followers in community development (Kemavuthanon and Duberley 2009).

There are more than 20,000 groups participating in this project. Leaders were identified as those who (a) allocated and coordinated tasks and (b) mediated between the customers and the government officials. In the study the authors used semi-structured interviews, focus groups, and member-check to ensure that the information gathered was accurate. Twelve leaders and 17 followers were interviewed. There were six leaders in each focus group (Kemavuthanon and Duberley 2009).

Buddhism has a strong influence in Thai society. In their research, they found that the most important characteristics for a leader are based on the Buddhist concept of the ruler: they should follow the right path, they should have self-awareness, humbleness, and they should be prone to make sacrifices. The participants also perceived that leadership has three levels: (a) benefits to oneself, (b) to the members of the group, and (c) to other people beyond the group (Kemavuthanon and Duberley 2009). Within these levels, *social justice* is practiced through actions based on goodwill, compassion, and equanimity to give benefits to others. Social justice is also expressed in this model through participation in the community, giving, helpful actions, and amicable speech.

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[11] To learn more about how social justice is viewed in a Buddhist perspective, refer to "Appendix I: Socially Engaged Buddhism."

[12] I wanted to include the following leadership model by Kemavuthanon and Duberley (2009) because I found it consonant with the Buddhist view, even if it was based on a research with Thai people; thus, it could be used in cross-cultural contexts too.

Research participants' responses were aligned to the belief that in order to be a leader one must (a) identify one's strengths and challenges and (b) undertake personal development first in order to be capable to help others develop their own capabilities. Community leaders believed in the need to develop themselves first before supporting the leadership development of others. Also the leaders were seen to follow ethics with a disposition to go beyond self-interest. And leaders were viewed as those who cared to support others to become more self-reliant and initiators, essentially helping others to develop their capacities to be leaders as well. Research participants also stressed that there must be a reciprocal relationship between leaders and followers (Kemavuthanon and Duberley 2009).

The authors noted that the findings of their study were aligned with Buddhism.[13] Based on their findings, the authors designed a three-level leadership model (Kemavuthanon and Duberley 2009 p. 749).

5.4.1 First Level: Actions to Benefit Oneself

To benefit others one has to develop oneself first. To safeguard others, one has to learn how to be one's own safeguard first. To become a type of servant-leader, under this framework, one has to pass through a process of self-development. Actions are centered on the guiding principles of ethics. Level 1 has three sub-practices: hand, head, and heart. By *heart* the authors meant a disposition to make sacrifices, to make good efforts in one's work, and to make actions of goodwill. By *head* they meant critical thinking, acquisition of knowledge, and listening. By *hand* they meant actions to develop one's capacities. The actions are targeted to the ultimate goal of this level: self-development (Kemavuthanon and Duberley 2009).

5.4.2 Second Level: Actions to Benefit Others

In the second level, the leaders' actions are focused toward others in their organization. The leader developed skills and knowledge in the first level, now his or her efforts are directed toward benefitting others in their quality of life and well-being. They become role models to others. They help the team reflect before taking an action and encourage them to keep developing themselves. In this level, there is collaboration between the participants and the leader (Kemavuthanon and Duberley 2009).

[13] In Thailand the major school of Buddhism that is practiced is *Theravāda*. Under *Theravāda*, there are ten virtues, in contrast with the six of the *Mahāyāna* tradition that I discussed in a previous section. Those ten virtues identified in *Theravāda* are generosity, ethics, renunciation, wisdom, effort, patience, truthfulness, resolution, love, and equanimity.

Actions created from the collaboration of leaders and followers are centered in helping.[14] These actions develop further the leader and also the followers. The actions are targeted to the ultimate goal of this level: to benefit one another and improve quality of life in the community (Kemavuthanon and Duberley 2009).

5.4.3 *Third Level: Interrelated Benefits*

Leadership in this level is a holistic concept that connects people from the inner and outer sides of the organization for mutual benefits. Leadership here becomes a learning process that starts when the leader influences the group to do actions beyond their self-interest which in turn brings mutual benefits to initiators, participants, and people beyond the group or organization (Kemavuthanon and Duberley 2009).

The authors related this level to Burn's *transformational leadership* where one or more people influence one another and keep influencing higher levels of motivation. They also saw an alignment between their findings and Greenleaf's *servant-leader*.

In the following section, I wrote a case scenario of a pre-college engineering design activity. I structured it around the framework of leadership that I described in the previous sections. Let us see how this framework might inform, influence, or perhaps enhance other models of engineering design.

5.5 Implementing the Framework in a Pre-college Engineering Case Scenario

I took inspiration to write this case scenario of a pre-college engineering design activity based on my readings about the Sarvodaya Shramadana Movement, one of the largest non-profit organizations of Sri Lanka. They apply the Four Noble Truths (taught by the Buddha in his first sermon) to village development and social aid.[15] They also apply Buddhist and Gandhian principles to create their village development programs.

5.5.1 *Description of the Scenario*

One way to present a model of engineering design in a Buddhist perspective is to frame it with the Four Noble Truths. In this case scenario, the students will identify

[14]This level is associated with the principle of *parattha*: our good deeds give benefits to others (Phra Dhammapitaka 2000, p. 9, as cited in Kemavuthanon and Duberley 2009, p. 751).

[15]More information at http://www.sarvodaya.org and Bond (1992).

one of their community's needs and create a solution to address it. The Four Noble Truths are the following:

1. The truth of suffering (or dissatisfaction)
2. The causes of suffering
3. The cessation of suffering
4. The way that leads to the cessation of suffering

In discussions about Buddhism, ecology, and the environment, the application of the Four Noble Truths has been discussed by many scholars (e.g., Ayya Tathaaloka Bhikkhuni 2010; de Silva 1998; Rinpoche 1997; Thurman 1997). In engineering design, the Four Noble Truths can be translated as: (a) the community problem, (b) its causes and conditions, (c) the plan to address the causes of the problem, and (d) the design to solve the problem (model).

In the following description, I connected each noble truth to social justice and a stage in engineering design.

5.5.2 *Pre-activity: Acquisition of Basic Knowledge*

Starting from what the students already know, the teacher will guide the students to understand the activity: why it is important, what they will learn during the activity and afterward, and how the knowledge will be translated into engineering practice, and so on. We can also include discussions about the community's relations with the economic system, cultural and societal issues relevant for them. The teacher will facilitate an introduction to engineering, sustainability, and basic research skills to help the students in their self-development process.

5.5.3 *The First Noble Truth: Suffering: What Is Our Major Community Problem?*

The students will participate in a group activity where they will investigate about community needs. Priority will be given to groups within the community whose basic needs have not been met or who have not received support to the kind of help they are requesting. Those could be, for example, women who stay in the community to care for their children, elders, nuns or monks who need support from the lay community to meet their basic needs, a minority group in the community, and so on. This prioritization is implemented to ensure that we address issues of social justice in our design project. The teacher will provide a questions guide. The students will interview community members in groups of three or four (or as advised by the community teacher). For example, if the community has a Buddhist nunnery, female students may request permission to ask nuns about infrastructure problems of the building and surroundings. They might also ask about how they are accessing food and potable water, for example.

5.5.4 The Second Noble Truth: The Origin of Suffering: What Are the Causes of This Problem?

This stage is part of the interview process. The aim is to let the students explore in more details the causes and conditions of the problem according to the people who experience this problem firsthand. The interview guide has suggested questions, but they are encouraged to explore others. For example, let us say that the girls, in stage one, reported that the nuns identified a problem in the building that began to happen after the construction phase of a building proximate to the nunnery. If the school has the resources, the girls can take a photo of the problem. Alternately the girls can do a drawing of the problem.

We can help the students to develop their critical thinking ability (and connect our questions to engineering ethics and social justice). For example: what do we know about the project nearby? What type of materials and techniques were used to build the nunnery walls? The teacher could ask the students: If you were one of the civil engineers in the construction site, what would you have done differently to prevent negative effects in other surrounding buildings or to compensate for negative environmental alterations in the vicinity? We can design more questions based on the eight approaches to solve ethical problems in engineering that Baillie and Catalano (2009) described: utilitarianism, rights to persons, virtue, freedom, chaos, morally deep world, globalism, and love.[16]

5.5.5 The Third Noble Truth: The Cessation of Suffering: What We Need to Do to Cease the Causes of the Problem?

This stage is also part of the interview process. It focuses on the possible decisions to cease the causes of the problem, according to the interviewee(s). The students will also ask the people in the community what would be the desired solutions. The people may also draw possible solutions to the problem to explain how they would solve it, with what materials, and considering the needs of women, children, elders, workers, or other special population to support social justice. The teacher will help the students in class to map those outcomes to engineering and science principles and language. He or she will also need to help them see which are feasible and which may be more challenging under the local constraints. Going back to the problem of the building, the teacher can help the students investigate the materials that compose the ceiling, the explanations in physics about how it was formed, if the same people in the community have suggested solutions, and feasible solutions that might be implemented with local materials to solve the problem.

[16] You can see examples on how they implemented them in case scenarios on pages 187–197 of their book.

5.5.6 *The Fourth Noble Truth: The Path to the Cessation of Suffering: What Is Our Solution (Model) to Address the Problem?*

After the teacher and students have mapped the problem in engineering and scientific terms, the students will brainstorm what possible solution can best address the problem. We can add social and health consequences related to the problem that they are facing. The teacher can encourage them to be mindful of the initial problem, the "constraints," and mindful that the solution will have an end. For example, considering a different case, let us say that they designed a tool to help elders transport buckets of water from one end of a building to another. In addition to cultural and societal considerations, it is important to understand what will happen to the technology after it ceases to be useful: What parts can be reused? Can it be recycled? We need to be mindful of the product lifecycle. To map the product lifecycle with Buddhist philosophy, we can reference the principle of impermanence.

The students can draw the design, make a small-scaled model reusing materials, and test the prototype (if applicable). Depending on the group that we are helping, we can ensure a more socially-just design process. For example, if the students in the community belong to an ethnic group, they may know of cultural motifs that can be painted on the artifact. Perhaps an elder in the community knows more about the art and can be invited to help the students. They may present the findings and possible solution to a non-profit organization that helps in sustainable community development or to the school's community. The design project may also serve as a way to support their self-confidence and demonstrate the potential of the students to work in engineering-related fields.

5.6 Analysis of the Case Scenario Using the Model of Engineering Design and the Leadership Framework Enriched by the Six Virtues

The engineering design activity I just described has six characteristics[17]: (a) it gives validation to knowledge coming from the people, (b) it maps that knowledge to science and engineering, (c) it helps the students connect with the community, (d) it is culturally relevant, (e) it seeks to help students to pass throughout the leadership stages of the framework, and (f) it seeks to put into practice virtues, attitudes, and values that can support social justice through engineering education.

Let us map each level of the engineering design model with the levels of the leadership framework. The process of leadership here appears to be like a spiral. For example, in the third stage of the engineering design activity, they need to "loopback" to review the knowledge acquired in the self-development (pre-activity) stage. Table 5.1 shows each stage of the activity mapped to each level of leadership:

[17]The first four points were implemented to be aligned with *culturally responsive education* (refer for example to Gay 2010; Eglash 2003, 2009).

Table 5.1 Mapping the stages of engineering design to each leadership level

Stages	Level in the leadership model of Kemavuthanon and Duberley (2009)
Pre-activity	1: Self-development: Basic knowledge of engineering and research Discussion of the community's relationships with the economic markets, environmental vulnerabilities and strengths. The community's history and socio-cultural issues might be also open here for discussion. If there are important laws applicable to engineers, they should be discussed too.
First stage	2: Benefits to others: In interview(s): Prioritization of those individuals whose basic needs have not been met Identify one problem that the people are experiencing Initial survey of the problem, based on the people's understanding
Second stage	2: Benefits to others: In interview(s): This level is an extension of the first. Still based on the standpoint of the interviewee(s). It focuses more on the *causes and conditions* of the problem. Based on the information that the students initially got in the questions guide, they might accommodate critical questions to the interviewee(s) (if it is allowed): When and how the problem started? What they know? What they think are the causes of the problem?
Third stage	2: Benefits to others: In interview(s): This section focuses in the *possible solutions* of the problem, still from the standpoint of the community What the interviewee(s) think could be a solution for the problem? How they would solve it? With what materials? Have they attempted to solve it before? What happened that they could not solve it? Probing for local knowledge of the people The interviewee(s) may also draw possible solutions 1: Self-development: The teacher guides the students to research about engineering and science knowledge that might support the local knowledge of the people: The students go through the interviews again for analysis and critical thinking For those areas that the people stated that they could not figure out a possible solution, the students might attempt to do initial drawings of the problem to help them understand it. They can also support themselves with science and mathematics principles. The students review or expand their knowledge learned on the *Pre-Activity Stage*, enhanced with critical thinking. They should integrate the local knowledge of the people, including ideas coming from their drawings
Fourth stage	2: Benefits to others: Based on the previous stages and guided by the teacher, the students start to create a model of the solution. It could be first a small-scaled model or drawing. Was someone with rich local knowledge identified? Can the person(s) help in the implementation of the solution? Can we invite others (e.g., women) in the community to be involved in one of the processes of the implementation? Do they wish so? Is it permitted?

(continued)

Table 5.1 (continued)

Stages	Level in the leadership model of Kemavuthanon and Duberley (2009)
	Arts and culture: Can the solution be decorated? Do the people wish to paint cultural motifs (e.g., traditional paintings) on the solution? Is there a shared religious or cultural activity they wish to perform? If so, the students should give space to the community to do so. 3: Benefits to others beyond the community: Depending on the context, the students and people involved in the design and implementation may present their project to others (e.g., to a non-profit organization that would like to support their project or to other people in other neighborhoods)

Fig. 5.3 The four noble truths (*left column*) translated into engineering design stages (*right column*)

The model of engineering design based on the Four Noble Truths, even if it is consonant with Buddhism, has the drawback of following the linear-industrial model of engineering design. Bucciarelli (1994) has critiqued this way of representing design because it assumes a reductionist ideal that does not match the reality of the design process. In reality, design is a social, cultural, and unstructured process of continuous negotiation and exchange of ideas among people (Bucciarelli 1994). In order to make a difference in the model of design (Fig. 5.3), the practice of the six virtues can be intertwined in each level. In the following subsections, I described how the practice of the six virtues may help in the process of negotiation and exchange of ideas that engineers (and engineering students) pass throughout the design process.

5.6.1 First Level of Leadership: Self-Development

Kemavuthanon and Duberley's (2009) model is aligned to the pre-activity and part of the third stage of engineering design (refer to Table 5.1, Level 1 at the right side column). The teacher guides the students in their way to acquire knowledge of engineering and research that is important before starting to interview people. The teacher and the students discuss about societal, historical, cultural, environmental, and economic situations relevant to the community in order to help the students develop what is called in engineering "systems thinking." They might clarify doubts about the importance of research in engineering practice: why we will interview community members, why it is important in engineering, how it can benefit others, and so on. This foundation of knowledge will set the ground to develop the strengths to go to the next level of leadership: benefits to others.

Remember that in Level 1 of Kemavuthanon and Duberley's (2009) model the focus is on the leader's self-development. In my case scenario, the virtues practices at this level work to benefit one's self-development, keeping in mind that the intention is to eventually benefit others. In this level, *patience* is an important foundation for perseverance. *Mindfulness* will help support patience in the learning process of the student, especially when needing concentration to grasp the way of systems thinking. *Joyful effort* can be associated to the perseverance that takes to comprehend engineering and science principles, knowing that it will be for the benefit of others. *Wisdom* translates into developing insights about the causes, conditions, and effects of phenomena and into learning from previous experiences; both types of wisdom supporting the systems thinking that is needed in the self-development of the engineering student. It might not be quite obvious how *generosity* and *ethics* play a role in self-development, but considering that the students are self-developing in order to help others, a spark of generosity and ethics is at the heart of self-development. Ultimately, in the next levels, generosity and ethics will play a more active role in the process of negotiation and exchange of ideas in engineering design.

5.6.2 Second Level of Leadership: Benefits to Others

Level 2 of the leadership model focuses in benefitting others. Once the student has acquired the knowledge in Level 1, then they interview the people in the community to understand their needs and wishes. In this level, we encourage the students to listen to the voices of the people in order to help find a suitable way to solve the problem. The students' activities of brainstorming, designing, and testing a prototype are part of Level 2 because they are processes necessary to help satisfy the needs of the people.

How does the practice of the six virtues map into this level? Recall that the practice is really an interrelated combination of six practices: giving, ethics, patience, perseverance, mindfulness, and wisdom. The students are *giving* their time and efforts to help solve a community's development problem. Guided by *ethics* and *patience* they are listening to the people's needs and exchanging ideas in teamwork. They will practice *perseverance* in order to support their systems thinking, and to learn engineering and science principles that can complement the local knowledge of the people. *Mindfulness* and *wisdom* will help them work on a design that takes into consideration the previous knowledge that was learned from their experience and the experience of other engineers. In short, during the process of designing a solution, they will be putting into action the six virtues to support their engineering design processes.

5.6.3 Third Level of Leadership: Benefits to Others Beyond the Community

According to Kemavuthanon and Duberley (2009) the ultimate goal of leadership is to engage in a holistic approach beyond self-interest to solve problems. In Level 3 of the leadership model, the students and community members benefit each other and extend the benefits beyond the community. In the last step, students will report their findings and proposed solution to a non-profit organization that helps in sustainable community development, to the school, or to other neighborhoods.

How does the practice of the six virtues relate to the third level? *Mindfulness* will help them to concentrate and organize a good presentation. *Ethics* and *patience* can be practiced while they respond to the audience's questions in the final presentation. *Perseverance* will guide them to set up the final model correctly to give a demonstration (if applicable) to the audience. *Generosity* is at the heart of this design for community project because students took care of learning about the community throughout the process of design. Ultimate *wisdom* does not have a parallelism in mundane terms because it is beyond words; however, we can speak of the results. For instance, the insights that they internalized can be transferred to other design projects as well. We can also say that the students will share their insights with other community members fostering more participation from and with the community. In addition, it can demonstrate to the audience the potential that the students have to become good engineers or technology-related specialists, no matter where they came from or who they are.

5.7 Conclusion

I have presented a framework of leadership based on the Buddhist view of ethical development. The framework consisted of Kemavuthanon and Duberley's (2009) leadership model and the practice of the six virtues of the *Mahāyāna* tradition of Buddhism. Through a case scenario,[18] I demonstrated how a model of engineering

[18] In 2012, I will implement a modified version of this case scenario, as part of my dissertation project. I will use the model of engineering design based on the Four Noble Truths and the framework of leadership to guide pre-college level Tibetan Buddhist students in their engineering design activity.

design based on the Four Noble Truths, within the framework of leadership and the practice of the six virtues, can help engineering students understand what engineering design is and make it more socially just. The framework of leadership can help engineering educators in Buddhist schools to design learning activities that will help the students develop leadership and virtues to support social justice. The framework may also be useful in cross-cultural or multicultural contexts.

The framework of leadership based on Buddhist philosophy not only can benefit students in developing leadership skills, but it can also be a framework to help engineering educators develop their leadership skills as well. For engineering educators who know little or nothing about Buddhism and face a circumstance where they need to learn something about it (e.g., they are mentoring a Buddhist student, or mentoring engineering students who are abroad doing a design projects in Buddhist communities, or simply are hungry for a philosophical alternative in engineering design), the content of this chapter can be an introduction to the perspective of Buddhism. The framework does not need to be limited to pre-college engineering education, though when I wrote the case scenario, I visualized that the activity was part of a program in an organization that helps vulnerable Buddhist populations in a resource-poor country, such as children in a foster home, pre-college students coming from disadvantaged families, or victims of human trafficking. Through this framework, the practice of the six virtues leads to becoming a more socially just engineering educator.

What other benefits can be obtained by bringing Buddhist studies into socially just engineering education? Here is a brief list of research areas that can be studied in the connection of Buddhism and socially just engineering education. First, scholarship on sustainability and Buddhist thought has been discussed by many authors.[19] A question worth exploring might be what elements in common have Buddhist thought and sustainable engineering?[20] Second, there are scholars interested on issues of social justice for Buddhist nuns and lay women.[21] It would be worthwhile to assess how socially just engineering projects can help support the basic needs of Buddhist nuns in disadvantaged areas of resource-poor countries. Third, there is growing scholarship on the potential of contemplative practices on student learning.[22] This area deserves more attention in engineering education research. Finally, we may consider researching how Buddhist thought has influenced engineers working on design for community or sustainable design.[23]

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[19] See for example: de Silva (1998), Kaza and Kraft (2000), Martin (1997), Tucker and Williams (1997). Some authors who have written about sustainability and Buddhism are categorized under "Deep Ecology."

[20] As an example, the cycle of corn-derived biofuel can be analyzed through the lens of *dependent origination* in a discussion on whether or not it can be considered sustainable in the long run. See for example Punnadhammo (2010).

[21] See authors who have published in Sakyadhita International Conference on Buddhist Women: http://www.sakyadhita.org

[22] See for example the Mind and Life Institute: http://www.mindandlife.org. In engineering education research, see the work of George Catalano.

[23] This final idea is of my interest and does not relate to social justice, nevertheless, it might be a good research area in Buddhist and engineering studies: the study of engineering design knowledge (and other concepts related to engineers and engineering) found in Buddhist scriptures.

In similar ways, teachers in Native American schools that adopted culturally responsive guidelines might interpret (with the help of their elders) the engineering design stages and practices through the philosophy of their culture. Ultimately, engineering educators can benefit greatly from learning the cultural, moral, and religious beliefs of the population they wish to serve in order to have greater impact and relevance with their work and, in the process, produce more socially just technologies and engineering practices.

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Appendix I: Socially Engaged Buddhism

Social justice in Buddhism is usually associated (in the West) with the *Socially Engaged Buddhism* movements that seek to connect Buddhist practice into daily life to alleviate or stop the suffering of societies. "Suffering" in this context is not just physical pain. When Buddhists speak about "suffering" they are also including the experiences of what would be called "social injustices" and "oppression." *Engaged Buddhism* is a term that has been attributed by Thich Nhat Hanh, a Vietnamese Zen monk. His 14 guidelines for Engaged Buddhism can be found on the Web or in his book "Interbeing: Fourteen Guidelines for Engaged Buddhism."

Engaged Buddhism is mindfulness in daily life, social service, and social activism (Puri 2006). These three aspects, not only connects with human rights, non-violent activism, environmental, social, gender, economic, and political issues, but also encourage people to bring the benefits of their practice in the ordinary life. These movements have taken a more international scope and democratic approach. Engaged Buddhism seeks to transform structures of oppression, bringing social justice to daily life, and empower people by acknowledging the Buddha nature in each of us, and our inherent worth and dignity. It seeks to do social justice activism, yet at the same time without discarding the Buddhist emphasis on mindful awareness and a lifestyle that is in harmony with the core teachings of the Buddha (Puri 2006).

Online resources for socially engaged Buddhism can be found in the Buddhist Peace Fellowship; alternatively in the Web sites of these organizations (not limited to): "Zen Peacemakers," "Prison Dharma Network," "Liberation Prison Project," "Sakyadhita International Association of Buddhist Women," "International Network of Engaged Buddhists," "Upaya Zen Center," "Metta Center for Nonviolence Education," "Peacemaker Institute," and "Buddhist Geeks."

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Chapter 6
How Can Engineering Students Learn to Care? How Can Engineering Faculty Teach to Care?

Ryan C. Campbell

Abstract This chapter focuses on a missing dimension to the traditional engineering experience: care, defined here as an active compassion, empathy, and concern for the wellbeing of other living (and sometimes non-living) things. The chapter begins with an introduction to the ethics of care, a normative ethical theory that emphasizes responsibility, relationship and context over rules and consequences. It then gives an overview of the engineering profession that shows the extent to which care is manifest in engineering practice. Throughout the chapter, a five element framework for care ethics adopted from the literature is used as a guide to demonstrate how engineers can become more effective at caring, particularly through work performed in philanthropic areas such as engineering for community service, disaster recovery, and international development—endeavors referred to collectively as humanitarian engineering (H.E.). However, in spite of the obvious opportunities for care in H.E., the practice of ethical caring is wrought with pitfalls, which are discussed, followed by way to overcome them through a proposed mindset that enables engineers to become more willing and better able to contribute constructively to issues of social and ecological justice.

Keywords Care ethics • Ethics of care • Humanitarian engineering • Engineering with community • Global development engineering • Engineering and care ethics • Empathy and care in engineering • International development engineering • Community service engineering • Engineering service learning • Engineering education • Sustainable engineering • Global engineering • Social justice • Ecological justice

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6.1 Introduction

Many of the inhabitants of Asia, Europe, North America, and other parts of the world are indebted to the engineers of the past and present for improving their lives through the practical and sometimes artful application of science to real world problems in fields as diverse as transportation, communication, and health care, just to name a few. However, engineering as a profession has historically served the needs and interests of only a limited portion of human society. In fact, not only have large numbers of people, including most in Africa and South America, failed to benefit from the work of engineers, many in countries around the world have even suffered, either directly from the weapons engineers created, or indirectly through unintended consequences related, for example, to pollution and environmental degradation created by technology and the levels of production and consumption technology has enabled. How then can we, as conscientious engineers of today, learn from the past and work toward a future that takes better care of both the people we profess to serve and the ecosystem in which we attempt to do so?

This chapter focuses on a missing dimension to the traditional engineering experience that is located, at least initially for engineering, in the non-profit sector. This missing dimension is care, defined here as an active compassion, empathy, and concern for the wellbeing of other living (and in some cases non-living) things. Although care is an explicit component of education in other service professions, such as nursing, medicine, social work, and teacher education, care and the related concept of empathy have never been a focus of engineering education. The definition of care I have adopted contains two aspects that are worth pointing out: (1) use of the word *active* indicates that care is a practice and involves work or taking action, and (2) use of the words *compassion*, *empathy* and *concern* indicate an important dispositional or motivational component to care. Indeed, as the literature on care ethics in a variety of fields clearly shows, the concept of care has myriad dimensions and can be defined in quite a number of different ways (Hamington and Sander-Staudt 2011). The second chapter of philosopher and care ethicist Virginia Held's (2006) book, which is arguably the most comprehensive examination of care ethics to date (Hawk 2011, p. 13), provides a review of the literature on conceptions of care that shows how care can be defined as an attitude, a motive, a value, a virtue, a relationship, a habit, a practice, work or labor, the meeting of objective needs, a normative concept (often contrasted with justice), and even combinations of these. This variability, rather than being a burden, can actually be advantageous because it provides the concept with a degree of *flexible adaptability* (Hamington and Sander-Staudt 2011, p. ix) with which it may be constructively applied to many different situations and conditions. In my usage of the term I wish to consider both the practice of care (e.g., the meeting of needs) and the attitudinal/motivational aspect of care because I join others (e.g., Riley 2008b; Lucena et al. 2010) in the belief that engineers must reflect on their motivations and consider how those motivations might affect their attempts to understand and constructively interact with others.

The chapter begins with an introduction to the ethics of care, a normative ethical theory that emphasizes concern, responsibility, and context over rules or consequences. I then give an overview of care in the engineering profession that shows how altruism and care are currently manifest in engineering practice. Throughout the chapter, a five element framework for care ethics adopted from the literature is used as a guide to demonstrate how engineers can become more effective at caring in work related to philanthropic programs such as engineering for community service, disaster recovery, and international development. I will refer to these endeavors collectively as humanitarian engineering (H.E.), which, although perhaps a patronizing designation (Vandersteen 2008, p. 297), is widespread compared to other possible designations[1] and conveys some of the intended sense of caring shared by these endeavors. However, in spite of the obvious opportunities for care in H.E, the practice of ethical caring is wrought with pitfalls, which are discussed, followed by a way to overcome them through a proposed mindset that encourages humble, dialogical and egalitarian interaction. This chapter shows that, through the opportunities for ethical caring H.E. provides, engineers have a distinctive opportunity to become more willing and better able to contribute constructively to issues of social and ecological justice.

6.2 Care Ethics Defined

In contrast to the somewhat ambiguous definitions of care mentioned above, definitions of the *ethics* of care tend to be more structured and concrete. While a comprehensive review of all extant definitions is beyond the scope of this chapter, it is

[1]While there are a few other terms in the literature that are perhaps less patronizing of the care-receivers, such as “engineering to help” (Schneider et al. 2009), “global development engineering” (Riley 2008b), and “engineering with community” (Lucena et al. 2010), none have anywhere near the widespread recognition of the term “humanitarian engineering.” As evidence for this prevalence, I point to the following:

- a North America-based scholarly journal with H.E. in its subtitle, namely the International Journal for Service Learning in Engineering: Humanitarian Engineering and Social Entrepreneurship (http://library.queensu.ca/ojs/index.php/ijsle/index) and an Australia-based journal with the title Journal of Humanitarian Engineering (http://www.ewb.org.au/explore/knowledgehubs/education/journal)
- academic minor and certificate programs of H.E., such as the Humanitarian Engineering Program at Colorado School of Mines (http://humanitarian.mines.edu/), and the Humanitarian Engineering and Social Entrepreneurship (HESE) program at Penn State University (http://www.sedtapp.psu.edu/humanitarian/about.php)
- a two part special issue of the IEEE Technology and Society Magazine entitled “Volunteerism and Humanitarian Engineering” (Vol. 28, No. 4 and Vol. 29, No. 1) and an IEEE conference titled Global Humanitarian Technology (http://www.ieeeghtc.org)
- the recognition of 2011 as the Year of Humanitarian Engineering by Engineers Australia (http://makeitso.org.au/yohe)
- various academic publications that employ the term, such as Mitcham and Munoz’s (2010) book, Passino’s (2009) journal article, and VanderSteen‘s (2008) Ph.D. dissertation

helpful to look at a few characterizations to understand the relationship between care and care ethics, as well as the relationship between care ethics and social justice. Indira Nair, professor of engineering & public policy, gives a concise description of care ethics as emphasizing "the importance of responsibility, concern, and relationship over consequences (utilitarianism) or rules (deontology)" (Nair 2005). Nel Noddings, feminist author and professor of educational philosophy, was one of the first to articulate an ethics of care. She distinguishes between natural caring, which, for example, most mothers gladly do for their children, and ethical caring, by which one is obligated to care regardless of one's own personal desire (Noddings 2003). Noddings also points out the important difference between care ethics and social contract theory: social contract theory assumes an egalitarian reciprocity that is often not possible in cases of ethical caring, such as those occurring in parent/child and teacher/student relationships.

6.2.1 Tronto's Framework for Ethical Caring[2]

Political scientist and care ethicist Joan Tronto (1993) has demonstrated how care ethics applies to not only the interpersonal or micro-ethical situations we commonly think about in regard to caring, but also to political/societal or macro-ethical situations. Tronto first frames care ethics primarily as a practice and describes four interconnected and frequently overlapping phases of the care process: caring about, taking care of, care giving, and care receiving. These phases then map to four moral elements of care: Attentiveness, Responsibility, Competence, and Responsiveness, respectively. Her conceptualization of care ethics are particularly helpful when applying care ethics to engineering later in this chapter, thus I will describe it here in some detail. Note that I use the terms "phases" and "elements" somewhat interchangeably in referring to these aspects of care/ethics because the distinction between care and care ethics is not always necessary and it is often helpful to keep the progressive and/or cyclic nature of care in mind through use of the term "phase" even when talking about the moral elements.

Tronto's first moral element of care, *Attentiveness* (c.f. caring about), involves awareness of the needs of others and makes the claim that neglect and even ignorance, be it willful or inadvertently habitual, are moral failings. Here she describes as an example the failure of many wealthy people in industrialized countries to notice (in spite of worldwide information & communication technology and diverse media coverage) how "activities spurred by a global capitalist system result in the starvation of thousands, or in sexual slavery in Thailand" (p. 128).

Tronto's second moral element of care, *Responsibility* (c.f. taking care of), involves the care-giver taking responsibility for his or her involvement in the care relationship, be that relationship voluntary or not. Here she makes the point that

[2]This sub-section is expanded and adapted from a conference paper written by the author (see Campbell, Yasuhara and Wilson 2012).

responsibility differs from obligation, because responsibility, being contextual rather than universal, is more ambiguous, and may not even be associated with prior actions of the care-giver. Here she points, as an extreme example, to the benevolent actions of Europeans during the second World War who, at great peril, tried to rescue Jews from Nazi persecution because they felt responsible simply by virtue of being human (p. 132).

Tronto's third moral element of care, *Competence* (c.f. care giving), indicates that the work of meeting an objective need of the care-receiver must not only be performed, but it must be done competently so that the need is in fact met. By making competence in care-giving a moral necessity, insincere attempts at care-giving are considered moral failings. While there may be reasons beyond the care-giver's control that impede adequate care, such as resource supply interruptions, as long as the care-giver does the best with what he or she has, the onus of any moral failing in Competence is on the party responsible for that resource deficiency. The example Tronto gives is that of a teacher required by his or her school to teach a subject in which he or she has no background. Since the students will not likely learn the intended material, it is the school's failing not the teacher's (provided the teacher has made reasonable efforts in good faith to redress the situation). This moral element of care is thus particularly pertinent to professional ethics, which has long been of interest to engineers and engineering educators. It provides ethical grounds for preventing "individuals to escape from responsibility for their incompetence by claiming to adhere to a code of professional ethics" (p. 134).

Tronto's fourth moral element of care, *Responsiveness* (c.f. care receiving), involves the reaction of the care-receiver to the care given and includes consideration of the problems of inequality and vulnerability that are present in any caring situation (p. 134). Responsiveness is the feedback loop by which the care-giver can determine if the care provided is accepted by and effective for the care-receiver. This moral element of care, like Noddings' conception of care ethics above, challenges the common notion underlying conventional ethical theories that all individuals are equal, self-supporting and entirely autonomous. The fact that power imbalances exist and that individuals are unequal, interdependent and even vulnerable has important implications at the societal level as well. This is essentially the link between care ethics and social justice (more on this in the next subsection).

Having described care ethics as a practice, Tronto adds to these four moral elements a fifth meta-level dimension, known as the *Integrity of Care*. The intended connotation of integrity here is cohesiveness, joining together or integration; thus, just as good care results from the four phases being well-aligned and collectively appropriate, the four moral elements must fit together as an integrated whole in a way that is sensitive to context and addresses the conflict that is inherent in any moral situation, be it micro- or macro-ethical as traditionally understood. The Integrity of Care can also be considered a disposition (Hawk 2011, p. 8) that provides a motivational dimension of care ethics, to which the four phases and moral elements add operational "legs" for enacting the process of care.

6.2.2 *Care Ethics in the Engineering Education Literature*[3]

In the engineering education literature, which I review below, care ethics has not attracted much interest to date. However, it has received considerable attention not only in the fields of philosophy, education and political theory as the previous section suggests, but also in fields that are more obviously related to care such as nursing and medicine. Care ethics has also received attention in the fields of law, business ethics (e.g., Hamington and Sander-Staudt 2011), stakeholder theory (e.g., Engster 2011), knowledge & creativity management, and accounting. For a concise but more comprehensive review of this wider literature, see Hawk (2011, pp. 16–17).

In the engineering education literature, the first mentions of care ethics appear as recently as 1997, when civil engineering educators Broome and Peirce, citing Noddings and Tronto, stressed "caring" principles as the motivation needed for engineers to become good, responsible, and even "heroic" in their practice (Broome and Peirce 1997). In 1999, Nair and civil engineering professor Pantazidou published the first engineering education journal article dedicated to understanding how care ethics might be manifest in engineering (Pantazidou and Nair 1999); they highlighted the service-oriented nature of engineering and illustrated its applicability to engineering design and problem solving methodologies by mapping aspects of these methodologies to Tronto's elements of care. Specifically, for design methodology they associated:

1. Attentiveness with the identification of need in the context of the state of the art
2. Responsibility with design conceptualization
3. Competence with feasibility analysis and production
4. Responsiveness with customer acceptance
5. Integrity with the iterative nature of design

Similarly, for problem solving a given need, they associated:

1. Attentiveness with defining the problem in context
2. Responsibility with selecting a solution
3. Competence with executing a solution
4. Responsiveness with verifying that the solution is appropriate for the context

Professional structural engineer Joshua Kardon (2005) conceptualized care as a "standard of care" that essentially serves as a measure of ethical adequacy of the exercise of the engineer's professional duties. In my view, this conceptualization aligns best with Tronto's Competence phase of care ethics, though Kardon demonstrated, through the use of multiple case studies, how all five of Tronto's moral elements could be used to evaluate the performance of engineering work against his "standard of care". Finally, engineering professor Donna M. Riley (2008b) gave brief indications of the importance of care ethics in relation to engineering and social justice.

[3]This sub-section is adapted from a conference paper written by the author (see Campbell and Wilson 2011; Campbell et al. 2012).

These conceptualizations, however, are somewhat abstract and lack an interpersonal nature of care as an active compassion, empathy, or concern for the wellbeing of others. One author who did well in articulating the interpersonal nature of care in engineering was electrical engineering professor Gene Moriarty. While initially published outside of the engineering education literature (see Moriarty 1995), he provided an excellent introduction to care in engineering in an interpersonal sense through the use of virtue ethics (Moriarty 2008). Tempering care with objectivity, he presented a balanced conceptualization for both good engineering and the good engineer. Similarly, chemical engineering professor William Bowen (2009) proposed an aspirational approach to engineering ethics (also based on virtue ethics) that is explicitly caring and bears some similarities to this chapter, though without drawing on the above-mentioned literature on care ethics. Another paper in which a form of care ethics was featured prominently and specifically (though also without reference to the above-mentioned literature on care ethics) was that of Hyde and Karney (2001) who described an "ethic of caring" for the environment that involved caring attitudes and behaviors. Finally, Strobel et al. (2011) recently performed a systematic review of the literature on the twin topics of empathy and care, searching databases of research in education, social science, engineering, nursing, medicine and counseling. They indicated a variety of ways in which care is conceived in engineering and suggested that it shows encouraging prospects for care in engineering today.

6.2.3 Care Ethics and Social Justice

Care ethics, as implied earlier, is linked to social justice because it blurs the line perceived in conventional ethical thought between the public and the private, and effectively removes the distinction between what is moral and what is political. The public and private realms are recognized as equivalent in ways that have never really been considered before the advent of care ethics and this reveals political activity as essentially a moral endeavor and conversely moral activity as inherently political. As professor of business management, Thomas Hawk, explains, "Caring is a process that requires ongoing communication and conversation among all those impacted by the moral judgments in the full spectrum from personal relationships to societal relationships at the level of the nation" (Hawk 2011, p. 10). The ethics of the public and private realms are fundamentally intertwined and to continue viewing them as entirely separate and distinct only serves to perpetuate existing injustices by permitting different ethical standards for each. For example, in the case of free market economics, this has the effect of replacing ethical choices (e.g., whom one should support financially) with choices that are seemingly value free (e.g., cheaper is better), but only illusory so because they benefit some (e.g., distant large-scale farms owned by corporations) at the expense and disadvantage of others (e.g., local small-scale farms owned by neighbors).

Since Tronto articulated this view of the distinction between public and private as a false dichotomy, others have attempted to integrate theories of justice with care ethics and/or to develop care ethics as a comprehensive ethical theory. While it is beyond the scope of this chapter to review all such attempts, it is helpful to consider a few prominent ones. Held (2006, p. 17) considers care ethics to be foundational to any moral theory: while care can occur in the absence of justice, there can be no justice without care because (1) every human life depends on the care of others from infancy through childhood, during times of illness, and in old age, and (2) without caring family relationships as a foundation, children would not survive and societies would not exist in which to make issues of justice even salient. In her view, justice is, however, a complementary and very important concept, both as it has traditionally been invoked in policy and law, and also in families and male-female relationships, where it has it has historically been neglected resulting in the unjust treatment of women. Professor of political science Daniel Engster (2007) similarly sees care ethics as "the heart of justice" and attempts to delineate "a minimal set of moral and political principles that apply to all people and societies regardless of how else they might choose to organized their private or public lives" (p. 4).

Perhaps the most directly pertinent theory of care ethics to social justice and humanitarian engineering is that of care ethicist and professor of philosophy Michael Slote (2007), who builds his argument on the importance of empathy for ethical caring using the term "empathic caring".[4] Slote makes the distinction between *sympathy*, which is merely feeling sorry or bad for someone, and *empathy*, which is characterized by actually feeling what another person feels. He further makes a distinction—as supported by research in the field of psychology—between two types of empathy: projective empathy, in which one must deliberately project oneself into the situation of the other, and mediated associative empathy, which is more passive, receptive and reflexive. It is this latter form of empathy that is the

[4]Given the applicability of Slote's version of the ethics of care to social justice and humanitarian endeavors, the reader might wonder why I have not adopted it instead of Tronto's framework for the analyses presented in this chapter. I have two reasons for this, one of which is pragmatic and the other philosophical. Pragmatically speaking, I find that Tronto's framework provides a clearer and better scaffolded conceptualization of care ethics that is closer, for better or worse, to the way engineers think. It thus provides a better, more developmentally appropriate introduction to care ethics than Slote's theory and even helps us see where conventional engineering mindsets might steer us wrong in our caring endeavors. From a philosophical point of view, I am reluctant to accept the notion in Slote's (and for that matter, Noddings') theory that humans have a lower level of responsibility of ethical caring for distant or lesser-known others than for those in close proximity. While there may be some truth to such a notion from the perspective of resource limitations, to say that international humanitarian caring is less important than caring for those locally in need seems to encourage an attitude of selfishness and tending one's own garden (Tronto 1993, p. 171) that would easily turn a blind eye to the impacts of one's actions on distant others. Such a position seems particularly problematic for non-human life and the ecosystem, much of which will always be distant and difficult to know in the way one can get to know people (at least with distant people one could move to a new region and make new friends, neighbors, and coworkers). Does this mean caring for the environment should always play second fiddle to caring for one's family or nation (e.g., through providing material or economic comforts)? How would matters of environmental pollution and sustainability be addressed? Slote admits that even the applicability of empathic caring to animals is complicated and daunting (Slote 2007, p. 19).

ideal for empathic caring since it is more natural and altruistic while the former may be forced or contrived. Neither type of empathy, however, involves a merging of identities of the care-giver and care-receiver: empathic individuals always retain their own identities. However, through experience and the exercise of moral imagination, it is possible to develop skills of empathic caring that are effective for caring for distant others and that even enable predictive capabilities whereby one feels what another would feel in other potential situations.

6.3 Care in the Engineering Profession

A brief look at the various roles played by the engineering profession is helpful in understanding where engineering is, were it is going, and the ways that care and concern for others can be, and in some ways already are, manifest in engineering. Mitcham and Munoz (2010), Lucena et al. (2010), and Riley (2008a) all offer perspectives on the history of engineering that inform the following subsections.

6.3.1 Engineers and the Military

According to Mitcham and Munoz (2010), the work of the first engineers was military in nature as it involved designing and operating fortifications and tactical devices such as draw bridges, siege engines and catapults. Even today, the ties of the engineering profession to the military run deep as indicated, for example, by the large number of engineers involved in defense-related industries (Bowen 2009; Riley 2008a). While it could be argued that in a military context, care is manifest in efforts to defend against the threats of the enemy, care and compassion are not ideas easily associated with military endeavors. In contrast to the war-time efforts of Red Cross doctors and nurses, who aid the injured regardless of alliance, it seems naïve to imagine a group of impartial engineers tending to the water purification or transportation needs of soldiers on either side of the conflict. Indeed, this would probably be viewed as treasonous, perhaps because the purview of such engineering work is in meeting higher level needs and conveniences (see Mitcham and Munoz 2010), rather than basic needs associated with fundamental human rights.

In terms of Tronto's framework, we can only imagine the care ethics that engineers might manifest in military endeavors. In a world that glorifies violence and spends exorbitant amounts of money and resources on warfare and defense (see Bowen 2009), an ethics of care that promotes non-violent alternatives to conflict has surely never been attempted. For example, rather than building weapons for destruction or deterrence, engineers might be commissioned to build language translation mechanisms that facilitate dialog and understanding between neighboring communities and countries. Rather than building technologies for deception, manipulation and control, they might find novel ways to create openness and trust so that disagreements over competing interests could be better negotiated and resolved without resorting to violence. Perhaps even more directly, Bowen (2009) makes the case that more engineering skills and services could be far better utilized in addressing some of the major causes of war, such as energy supplies (e.g., by providing alternatives to oil and gas), and water resources (e.g., by using existing technologies to provide sanitation and safe drinking water for all).

Even within the context of military engineering and weapons building, there are opportunities for engineers to begin practicing care ethics. For example, as Bowen (2009) points out, the majority of the victims of engineered weapons, such as cluster munitions, are innocent people and often children. Care ethics in this context might involve designing weapons that are capable of accurately discriminating between military and civilian targets, or that are difficult to use in ways that contravene international conventions and treaties.

6.3.2 Engineers in Industry, Government, and Commerce

The Industrial Revolution created demand for professional engineers with a civilian focus for the design of machinery, irrigation & drainage systems, roads, dams, and related infrastructure (Mitcham and Munoz 2010). Coupled with industrial scale production came large-scale consumption, which has created even more opportunities for engineers across virtually all sectors of the economy not only in the primary "raw materials extraction" sector and the secondary "manufacturing" sector, but also in the tertiary "services" sector with jobs in such fields as consulting, information & communication technology, and even entertainment. Note, however, that the number of engineers and their roles in each of these sectors are limited by the size and developmental level of the economies of which they are a part. In regions where industrialization has not occurred (i.e., the so-called developing world), many of the benefits of engineering, as conventionally conceived, may be impossible to realize.

Looking at engineering through the lens of these economic sectors might give the impression that engineering talent tends to follow power and money; however, as Lucena et al. (2010, chapter 2) show, the reality is more complex. Engineers have indeed been involved in supporting imperialism by building machinery and infrastructure to facilitate the extraction of raw materials from colonial lands and subjugate indigenous people as slave laborers. However, engineers have also been involved in locating and extracting resources and building infrastructure in their own countries for the purpose of nation building and creating public works for the use and convenience of their fellow country people. For many, the motivation to contribute to the common good has surely been a driving consideration, as evidenced by engineering attempts in early twentieth century America to unify as a profession against the interests of corporate business for ostensibly altruistic purposes (Layton 1986). Furthermore, even while some engineers were involved in colonial and nation-building efforts, some have been involved in arguably more philanthropic endeavors as will be described in the subsections to follow.

When we look at the economy from the perspective of ownership, we see that the public sector enjoys the talents of engineers working at many levels and in many areas of the government, from departments of defense, to environmental protection agencies, to electric power utilities at the national, regional, and municipal levels. In the private sector, engineers work for multitudes of companies and corporations or even freelance as consultants and contractors. However, in spite of this variety of employment opportunities, and unlike some of the more people-centered professions, such as medicine and law, engineering is not known to be a particularly caring profession. In fact, according to the findings of a study conducted by Harris Interactive in 2003 (see NAE 2008), the American public perceives engineers as being significantly less sensitive to societal concerns and less caring about the community than scientists. While there are logical reasons for engineering's poor public image, such as the fact that engineering work is often not conducted in physical or temporal proximity to the end user (Bowen 2009) and thus precludes the personal relationships that doctors enjoy with their patients, it is interesting to note that the idea of pro-bono work to aid those in need has historically not been part of the culture of engineering (Baum 1985).

Like engineering in military contexts, the idea of care and concern for others in civilian engineering employment is also somewhat hard to imagine. Perhaps this is due to the problem of engineering's complicity in a materialistic capitalist economy that tends to commodify even human relationships.[5] Pantizidou and Nair's conception of design and problem solving as care, or Kardon's standard of care (see Sect. 6.2.2 "Care Ethics in the Engineering Education Literature" above) might thus be adequate descriptions of care as presently instantiated in these sectors. In terms of Tronto's framework, the Integrity of Care (as a disposition) appears to need development in secular engineering employment. Engineers working in imperialist settings seem to need work on all stages of care, starting perhaps with improving attentiveness to needs other than their own. For engineers involved in public works and nation-building, consideration of care ethics might point to deficiencies in attentiveness to the needs of the environment or to future generations who will be deprived of the opportunity to benefit from undepleted natural resources and unpolluted public lands.

6.3.3 Engineers as Technical Volunteers

Engineering roles in the non-profit sector over the past century have largely been limited to voluntary work performed under the auspices of technical societies, such as the American Society of Civil Engineers (ASCE) and the Institute of Electrical

[5]Moriarty (2008) articulates this well as "[t]he problem with an economy in the grip of the capitalist "take" on reality is that everything becomes commodified and human relationships become purely functional and instrumental. An attitude of respect for persons becomes more and more difficult to maintain." (p. 58) and "…capitalism implicates engineering almost totally in its cycle of commodification, production and consumption" (p. 91). My gratitude to the anonymous reviewer who suggested the addition of this point.

and Electronics Engineers (IEEE), as well as professional associations, such as the National Society of Professional Engineers (NSPE) and the National Council of Examiners for Engineering and Surveying (NCEES). The mission of such organizations is usually to serve the interests of the engineering discipline or profession, its members, and ideally, the public. For example, the IEEE, which is the world's largest professional association for the advancement of technology with over 320,000 members in 1997, indicated in its mission statement:

> The purpose of … [our] activities is twofold: (1) to enhance the quality of life for all peoples through improved public awareness of the influences and applications of its technologies; and (2) to advance the standing of the engineering profession and its members.[6]

While these goals are technically- and somewhat inwardly- (toward the profession) focused, they are clearly more altruistic than those of industry and business, which usually aim to serve only themselves and their shareholders. Indeed, a desire to be more outwardly- and societally-focused is reflected in the revised and updated IEEE Mission and Vision Statement, which today reads:

> IEEE's core purpose is to foster technological innovation and excellence for the benefit of humanity.
>
> IEEE will be essential to the global technical community and to technical professionals everywhere, and be universally recognized for the contributions of technology and of technical professionals in improving global conditions.[7]

To the extent that mission statements are a reflection of the collective motives and practices of a profession, over the past decade IEEE has moved from merely promoting technology for enhancing quality of life via improved public awareness of technology to fostering innovation for the benefit of humanity. Similar statements can likely be found for other engineering organizations as well. Arguably, this broadening of focus away from the profession and away from technology for its own sake to technology for a larger purpose can be viewed as evidence of an increasingly caring profession. While one might question the magnitude of changes in practice to which these assertions actually lead, I am optimistic that articulating such goals is part of a process that helps bring more diversity of thought into engineering, which will in turn encourage further reflection and thereby progress toward effective change. In terms of Tronto's framework, perhaps here too Pantazidou and Nair's conceptions of design and problem solving as care and Kardon's standard of care (see Sect. 6.2.2 "Care Ethics in the Engineering Education Literature") are adequate descriptions of care as presently instantiated in this context, but there is also evidence of development of the Integrity of Care as shown by the increasing Attentiveness expressed by concern for a larger purpose.

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[6]From a 1997 archived version of the IEEE website, About IEEE, "The IEEE Is … Achieving Goals". Retrieved 13 January, 2012 from http://web.archive.org/web/19970225053543/http://www.ieee.org/i3e_blb.html

[7]IEEE Vision & Mission. Retrieved 13 January, 2012 from http://www.ieee.org/about/vision_mission.html

6.3.4 Engineers as Philanthropists

Since the early days of engineering as a profession, there have surely been individual engineers who have quietly found ways to contribute their time and skills to various humanitarian efforts. For example, engineers may have been involved as missionaries seeking to alleviate poverty, suffering, and excessive labor through the application of their engineering skills while simultaneously actively promoting their religious beliefs. There have also been a few individual engineers that have captured the attention of the media and government, such as Fred Cuny (Anderson 2000; Pritchard 1998) and Maurice Albertson, founder of the U.S. Peace Corps (Mitcham and Munoz 2010). However, engineering as a profession has only recently begun to seriously entertain the idea of such forms of altruism and caring. IEEE's revision of its mission and values is perhaps indicative of this.

Carl Mitcham identifies a movement of "idealistic activism" that started prior to the 1950s among scientists and engineers: exemplified by such organizations as the Pugwash Conferences on Science and World Affairs and the Union of Concerned Scientists (Mitcham 2003; Mitcham and Munoz 2010). However, the first engineering-specific organizations of this sort did not appear until the 1980s inspired by Médecins sans Frontiéres (MSF a.k.a., Doctors Without Borders), which was founded a decade earlier. Over the past 30 years, organizations with similar names and objectives, such as Ingénieurs sans Frontières (ISF), Engineers Without Borders (EWB), and Engineers for a Sustainable World (ESW), have emerged independently across the globe. Many of these organizations have recently joined an international network known as Engineers Without Borders International (EWB-I), which was co-founded in 2002 by the founder of Engineers Without Borders USA (EWB-USA).[8] EWB-I currently lists 32 member groups, 13 start-up groups, and 5 affiliated EWBs from across the globe. Another potentially large and recent endeavor is the founding of Engineers for Change (E4C) by the American Society of Mechanical Engineers (ASME) in collaboration with the IEEE, and EWB-USA. This online platform for collaboration and resource sharing brings together engineers, technologists, social scientists, non-governmental organizations (NGOs), local governments and community advocates on seven areas of interest: water, energy, health, structures, agriculture, sanitation, and information systems.[9] While the number of engineers involved in humanitarian engineering endeavors is probably not very large compared to the total number of practicing and matriculating engineers, it is rapidly growing. For example, EWB-USA, which incorporated in 2002 with 8 students and 1 professor, reports 8 years later as having 12,000 volunteers from over 180 student chapters and over 70

[8] See "Proposal to Establish EWB-Global", accessed 2 March, 2013 at http://www.ewb-international.org/pdf/EWB-I%20Proposal%2004%20June%20-%20Final.pdf and the CV of EWB-USA Founder, Bernard Amadei, accessed 13 January, 2012 at http://www.ewb-usa.org/theme/library/about-ewb-usa/ewb-usa-board-Bernard-Amadei.pdf

[9] Retrieved 30 March, 2012 from https://www.engineeringforchange.org

professional chapters. In 2010, they sent 1,297 students and 729 professionals to partner with 240 communities in 45 countries around the world.[10]

In terms of Tronto's framework, engineers working in philanthropic settings like those described above might have their hearts in the right place in being attentive to the needs of other and dispositionally oriented toward an Integrity of Care; however, at the risk of being overly critical, I must point out that the desire to care and the ability to do caring work are not the same. While the desire to care is normally an important prerequisite for choosing to give care, there is no guarantee that one's intentions are automatically achieved merely by the will to act. The attentiveness element of ethical caring demands sensitivity to the actual needs of the care-receiver rather than needs created or projected by the care-giver, and the responsiveness element demands a respect for the beliefs and wishes of the care-receiver that seems problematically neglected by proselytism, be it religiously motivated or driven by unconscious and unquestioned promotion of a particular economic system or ideology. The next section expands on issues such as these.

6.4 Barriers and Next Steps to a More Caring Engineering[11]

A key problem faced by the practice of humanitarian engineering is that of doing more harm than good (Lucena et al. 2010; Schneider et al. 2009; VanderSteen 2008). A number of important issues that humanitarian engineers need to consider can be gleaned from the literature. As members of a profession that is easily characterized as being narrowly focused and unreflective, engineers are particularly at risk for repeating past mistakes made in the fields of international development and global health. One such potential mistake is the tendency to promote the exclusively top-down planning approaches decried by Easterly (2006), who's critique of "planners" is especially pertinent to engineers: "A Planner thinks he already knows the answers; he thinks of poverty as a technical engineering problem that his answers will solve" (Easterly 2006, p. 6). Easterly's portrayal of "searchers" sets the stage, I believe, for a better alternative: "A Searcher admits he doesn't know the answers in advance; he believes that poverty is a complicated tangle of political, social, historical, institutional, and technological factors."

Another issue of concern is the importance of being critical of one's motivations to help others and maintaining humility about one's ability to do so (Schneider et al. 2009; Lucena et al. 2010). Being invited to learn from and work with a community or to help amend injustices involves a very different mindset than that of charity work, which risks being paternalistic and even undesired by the recipient. If we are

[10] Retrieved 13 January, 2012 from http://www.ewb-usa.org/about-ewb-usa/annual-reports

[11] Portions of this section are adapted from a conference paper written by the author (see Campbell and Wilson 2011)

sincere in our desires to help and willing to do the work that effective caring involves, we must set aside our egos and desires to feel good about ourselves, and proceed with humility.

A third issue of concern is that engineers, trained with a narrow technical focus, are likely to be oblivious to the broader cultural, political, and economic contexts, such as neoliberalism[12] and globalization, that have created the needs—real or perceived—they are stepping in to fill (Schneider et al. 2009; Lucena et al. 2010). The communities they wish to help, however, are more likely to be aware of these contexts and of the inequities that rich countries helped to create (Schneider et al. 2009) and thus may be skeptical of, or even hostile to offers of assistance. Engineers must be cognizant of these contexts and should call on the expertise of other disciplines, such as the humanities and social sciences (Lucena et al. 2010), to help them understand, appreciate, and incorporate these contexts into their work.

Related to this is the issue of insufficient organizational learning. Effective long term evaluation, as well as learning from past experience—both successes and failures—is essential and really only possible through cross disciplinary organizational understanding. While there is evidence of movement in the direction of improved accountability through self-reflection on problems due to technical, communication and cultural issues, little effort appears to be made toward understanding how systemic inequities may create patterns of failure across multiple projects (Riley 2008a). Hopefully the recent movement toward admitting and learning from failures in international development in general, and in humanitarian engineering organizations in particular,[13] will enable and encourage broader reflection and promote accountability.

Accountability has also been identified as an issue of concern: Riley (2008a) points out that there is presently little accountability to the target communities by existing humanitarian engineering programs and organizations. This is also true of most NGOs in international development who tend to be more accountable to their donors than to their beneficiaries (HAP 2010). A final issue of concern is directed at student involvement in humanitarian engineering work under the rubric of service learning, which has the potential to create exploitive relationships between privileged students and "developing" communities (Schneider et al. 2009) whereby students gain real-world experience, but communities end up with unworkable or short-lived solutions.

[12] Neoliberalism, defined as a "fanatical form of capitalism that places ultimate faith in private property, free markets, and free trade, privatizing industries and lifting any government protections on trade, the environment, labor, and social welfare" (Riley 2008a, p. 7), is criticized as being responsible for increasing disparities in wealth and opportunity, exploiting labor and the ecosystem (Harvey 2005), and along with the prevailing culture of positivism in society, is even complicit in stripping education of its true value and meaning (Giroux 2011).

[13] See EWB-Canada's Admitting Failure website (http://www.admittingfailure.com) as well as the information & communication technology for development (ICT4D) community's FailFaire conferences (http://failfaire.org).

Humanitarian engineers must find ways to take responsibility, follow through, and follow up to avoid inadvertently taking advantage of these vulnerable populations they aspire to help. As Schneider et al. (2009) point out, altruistic motives must, at minimum, be transformed from mere sympathy to genuine empathy before any actions taken by well-meaning engineers will be of lasting benefit to the communities they wish to assist.

6.4.1 Ethics of Care as a Guiding Framework for Social Justice

As Sect. 6.3 “Care in the Engineering Profession” has shown, there is evidence that practicing and aspiring engineers are increasingly interested in creating more explicit opportunities to manifest care and concern for others in their work. The task before us then is to help engineers move beyond good intentions and contribute constructively, and however modestly, in their endeavors to save the world. As mentioned above, it is unfortunately all too easy to care about someone or something and yet be entirely ineffective in actually *caring for* the object of concern. Something more than concern and willingness to take action is needed. As Held (2007) aptly stated, “when benevolent concern crosses over into controlling domination, we need an *ethics* of care, not just care itself” [emphasis in original]. An ethics of care is similarly needed to ensure that care work performed meets the needs of others and that the needs are in fact accurately understood.

In terms of Tronto’s framework, looking across the whole of the engineering profession we could say engineering appears to be in the first three phases: starting to be Attentive by recognizing the needs of others, becoming increasingly motivated to take Responsibility, and moving into the Competence phase of care. Effort must be made not to skip steps in Tronto’s framework by trying to enter the phase of Competence before that of Responsibility, as the issues of accountability mentioned above might suggest are occurring. What is needed, then, are means to help engineering students, educators and practitioners to understand and apply care ethics in engineering contexts so that they can become better at

1. recognizing and understanding needs, their causes (e.g., neoliberalism—see footnote 12), and the possible effects/constraints associated with those causes
2. taking an appropriate level of responsibility for addressing those needs (and for their causes)
3. performing the work of care in a competent manner, i.e., in a way that also addresses the underlying causes of those needs rather than just treating symptoms
4. working with the care-receivers at all project stages and reflecting on feedback as to the effectiveness of care-giving efforts
5. practicing a holistic “integrity of care” that strengthens and develops the quality of care engineers are capable of providing

Lucena et al. (2010) address many of these issues by promoting (a) active/contextual listening techniques that improve Attentiveness and Responsiveness,

(b) self-reflection on motivations, which provides Integrity and improves both Responsibility and Competence, and (c) participatory techniques that engage care-receivers thus enabling Responsiveness and improving Competence.

6.4.2 The Problem of Paternalism and How to Avoid It

In my view, Pantazidou and Nair's conceptions of design and problem solving as care and Kardon's standard of care (see Sect. 6.2.2 "Care Ethics in the Engineering Education Literature") represent important first steps toward understanding care ethics in engineering. However, these conceptualizations seem to lack the essential altruistic and interpersonal nature of care. Furthermore, while Tronto's framework, upon which they build, is helpful in thinking about the ethics of care in engineering, there is something fundamentally paternalistic[14] to it in the context of humanitarian engineering work since it seems to encourage, if not require, heroic care-givers and helpless care-receivers. With faith in technology and mindsets geared toward problem solving (Lucena et al. 2010), engineers are prone to adopting a hero mentality that at best is not helpful for community development work and at worst can be harmful. Engineering, if it is to be a conscientious agent of change for the better, rather than a blind tool that ultimately serves to perpetuate injustice, needs an ethic of care that addresses the problems of paternalism.

For the sake of comparison, an ethics of care that follows Tronto's framework in the field of medicine might seem reasonable and appropriate in many cases because the relationship between doctor and patient is inherently unbalanced by the relatively high level of education, experience, and skill possessed by the doctor. While a similar differential in education, experience, and skill might exist between an engineer and, say, a group of villagers, a key difference is that, except in the possible case of disaster recovery, the purpose of the humanitarian engineer is not to effect a one time cure through the careful diagnosis and prescription of some temporary measure. Instead, the humanitarian engineer must understand the needs of the community and its resources, be they natural, technological, or human capability, to thereby effect not a one time cure, but to catalyze ongoing and sustainable improvement in the community's quality of life in a way that is not only desired by the community, but also engages and integrally involves the community in its own development so that the improvement is continuous and self-sustaining long after the engineer departs. How then should engineers approach meeting the needs of others? Held (2007, p. 32) expresses great hope for care ethics because:

> Care has the capacity to shape new persons with ever more advanced understandings of culture and society and morality and ever more advanced abilities to live well and cooperatively with others.

[14]Tronto acknowledges paternalism as problematic (p. 145), but does not seem to offer any solutions or practical work-arounds. However, she does point out that at least through care ethics one can recognize and identify such issues and this is surely preferable to sole reliance on a moral theory that can not.

One way to think about this issue is through Slote's (2007) notion of empathic caring and the idea of mediated associative empathy that was introduced earlier in Sect. 6.2.3 "Care Ethics and Social Justice". This conception of empathy encourages the respect and autonomy necessary for limiting paternalistic actions on the part of the care-giver.

In the interest of building on Tronto's framework, rather than adopting Slotes' theory (see my reasons for not doing so in footnote 4, Sect. 6.2.3), I find it helpful to incorporate a concept known as the I-Thou relation[15] as presented by philosopher Hans Georg Gadamer (2004, pp. 352–255), who describes three possible modes in which people can choose to relate to others. The first mode involves an objectifying attitude toward the other that is dehumanizing and treats the other as merely a means to an end. This is not unlike the way a detached scientist might regard a research subject whom they value only as a data source. The second mode acknowledges the other as a person, but is self-oriented and paternalistic, viewing the other as one inferior through a mind closed to learning about the other. This is not unlike the way a knowledgeable doctor or teacher might condescendingly regard a patient or student they have evaluated, since the expert knows best and the other is deficient by virtue of his or her role as patient or student. True dialog and reciprocal communication in both of these modes of interacting with others is impossible because the other is not viewed as possessing a perspective worthy of learning about through open dialogue. In Gadamer's third mode of relating, the other is viewed as an equal with whom open, respectful, bi-directional communication is possible. This is a reciprocal and honest relationship not unlike that of friends or colleagues.

If truly ethical caring is to occur between an engineer and those he or she is hoping to help, then it is only this third mode of a care-giver relating to a care-receiver that can result in effective action because only then will true and effective Attentiveness and Responsiveness be possible. Any other way of relating to care-receivers risks (a) projecting needs on them instead of being open and attentive, and (b) paternalism and creating dependency rather than providing ethically competent care. We must be careful not to cross the line between care and paternalism, or between caring too much for ourselves and thereby creating unintended risks of exploitation. To overcome this problem, we must make effort to relate to those we might wish to help using Gadamer's third mode through mindsets of equality, humility, and respect.

6.4.3 *Engineers as Humanizing Activists*

If we are genuine in our desire to help, we must be willing to uncover and understand real needs and their causes, take responsibility, perform the work of meeting the needs, and solicit, accept and learn from feedback provided. This will involve humility and patience as we learn from other cultures and societies. One thing we in

[15]Note that Bowen (2009) also employed a variation of the I-Thou concept (though based on Martin Buber's original conception), which, while useful for discussing issues of proximity, does little to help with the problem of paternalism.

the global North should do is stop viewing those in the global South as "less than" (Schneider et al. 2009) and instead look at those in the so-called developing world as noble and intrinsically valuable people from whom we could probably learn a thing or two about simplicity, efficiency (i.e., the ability to do much with few resources), generosity, family values, and spirituality.

In the area of information and communication for development (ICT4D), there is a growing awareness of the need for a new view of poverty (Heeks 2008) and constructive approaches to dealing with it that are enabling of human capacity rather than dependency-creating, as welfare and charity can often become. Indeed, Heeks describes a progression in the ICT4D community as following that of the appropriate technology movement of the 1970s: a progression from innovation *for* the poor (pro-poor) to innovation *with* the poor (para-poor) to innovation *by* the poor themselves (per-poor). While Heeks does not go this far, I contend that the role of the humanitarian engineer might be better viewed as that of a builder not of hardware, software, or infrastructure, but of human capacity. The views of Paulo Freire (2000) seem remarkably appropriate here with regard to the humanizing and dialogical relationship he admonishes those in leadership to establish in liberating the poor from their condition. Engineers desiring to work in humanitarian engineering might do well using techniques of Freirean critical pedagogy in order to first become aware of their own roles and complicity in the power relationships that create and maintain poverty in the global South (see Riley 2008b for an example of what critical pedagogies might look like in an engineering ethics course). Once these issues are understood, aspiring humanitarian engineers can begin working on ways to improve social justice both from home through their various social, political, and/or religious affiliations, and in the field by catalyzing and providing support for indigenous grass roots solutions to social problems.

6.5 Conclusions

In this chapter I have introduced the ethics of care as a guiding framework for the engineering profession in achieving its noble aspirations to save the world. I have examined care ethics in the various traditional and emerging purviews of engineering, and discussed barriers to a socially just humanitarian engineering practice. Finally, I have described a way to overcome what I perceive as a key problem for ethical caring in humanitarian engineering, that of paternalism.

One contribution of this chapter has thus been to identify humanitarian engineering as providing an important pedagogical tool for incorporating care as a missing dimension to engineering education. This tool, if used wisely, can enable engineering practice to advance rather than impede social justice.

In summary, I believe the ethic of care needed in engineering to address issues of social justice can be described as promoting altruism, humility, cooperation, reflection/action (i.e., Freirean praxis), and concern with addressing the non-technical root causes of problems rather than simply treating symptoms with technical fixes.

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Part IV
What Gets in the Way and How Can ESJ Live in the Engineering Classroom?

Chapter 7
Crossing Knowledge Boundaries and Thresholds: Challenging the Dominant Discourse Within Engineering Education

Caroline Baillie and Rita Armstrong

Abstract In this chapter we argue that the 'common sense' ways of thinking in the engineering community need to be transformed if we are to engage in a meaningful way – that is, to conceptually understand and to practically address – the different inequalities which exist in the world today. We suggest that different kinds of knowledge need to be embedded within engineering curricula if students are to be become critical and self-reflexive thinkers and we further argue that this knowledge, because it is by definition transformatory, form a set of 'threshold concepts'. We discuss how an interdisciplinary team of scholars mapped a set of concepts which they felt were crucial to understand a world characterized by ecological and economic instability, and increasing disparity in wealth. Each of these has the potential of being a 'threshold concept', that is, of transforming conventional engineering ontology. These concepts emerged from a research group representing different disciplines – engineering, philosophy, law, history, Indigenous Studies – but here we focus on the knowledge negotiation between anthropology and engineering to illustrate how this process takes place.

Keywords Threshold concepts • Thought collectives • Discipline boundaries • Dominant discourse

7.1 Introduction

The desire to be socially just rests on the assumption that we know what injustice looks like, and that we wish to redress it in some meaningful way. Arriving at these shared assumptions is no small task and it has long been acknowledged that our

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inability to recognize not only our own subordination, but that of others, is hampered by adherence to values which perpetuate systems of inequality. The way in which knowledge is imparted, embedded, and put into practice has profoundly affected the social, cultural and economic landscape in which we live. This has been observed by many educators and theorists from Freire (1970) to Bourdieu (1977) who argue that the production of knowledge in schools and universities becomes internalized as 'taken for granted' or 'common sense' values. Bourdieu's definition of common sense – as a form of hegemony rather than practical reasoning – "includes those things commonly known or even tacitly accepted within a collectivity; it includes as well the consensus of the community as articulated in a variety of public discourses; and finally, it includes the sense of community that this commonly-shared sense of the world provides" (Holton 1997, p. 39). For Bourdieu, as Holton points out, common sense is historically and culturally grounded in specific communities. It is a "subjective but non-individual system of internalized structures, common schemes of perception, conception and action, which are the precondition of all objectification and apperception; and the objective co-ordination of practices and the sharing of a world-view" (Bourdieu 1990, p. 60).

We believe that some of the 'common sense' ways of thinking in the engineering community need to be transformed if we are to engage in a meaningful way – that is, to conceptually understand and to practically address – the inequalities which we face in the world today. We include here the 'world views' of both the student and the graduate currently practicing in the corporate workplace. In this chapter we suggest that different kinds of knowledge need to be embedded within engineering curricula if students are to be become critical and self-reflexive thinkers and we further argue that this knowledge, because it is by definition transformatory, form a set of 'threshold concepts' (see Meyer et al. 2010).

The chapter is co-authored by an engineering professor and an anthropologist who co-teach introductory and elective programs for engineering students which aim to assist students to think critically about social justice as it relates to the engineering profession. By doing so, they themselves work at interdisciplinary boundaries which enable them to be self-reflexive and to critically question their own assumptions and bring those to the classroom. This is a key part of an interdisciplinary curriculum design process.

7.1.1 Engineering Thought Collectives

It can be argued, as within any community of practice, that engineering students as well as practitioners and educators live within a kind of 'common sense' that they have developed from their teachers and books and from the external social constructs of their society. Fleck's work on thought collectives is useful here as it helps us to investigate the social conditioning of thinking. Thought collectives are not to be understood as a fixed group or social class; they are functional …

rather than substantial, and may be compared to the concept of field of force in physics. People can belong to many different thought collectives, but according to Fleck:

> The individual within the collective is never, or hardly ever, conscious of the prevailing thought style, which almost always exerts an absolute compulsive force upon his thinking and with which it is not possible to be at variance (1979, p. 41).

Fleck argues that stable thought collectives form around organised social groups (such as professional engineers), and that a large group exists long enough, the thought style becomes fixed and formal in structure. He also argues that the longer a thought has been conveyed within the same thought collective, the more certain it appears.

Fleck considers dominant ways of seeing/understanding the world within a given community of practice or thought collective. This has obvious connections with the ideas of Gramscian 'hegemony', or what seems common sense to a community. Hegemony, then, is considered a process of social control which is subtle in that it is not evident or even potentially conscious control – but it is carried out through the moral and intellectual leadership of a dominant sociocultural group. The most important element is that this hegemonic sense is regenerated by the community who accept it as common sense. Thus, the 'common sense' which a group of people share and understand is of course not at all 'common' to everyone.

We argue that engineering may be considered a particular community of practice, with an associated common sense and thought style. One feature of this 'thought style' which is particularly troublesome to shift – because it is tacitly accepted across all disciplines – is that of working within the model of economic growth, efficiency and productivity. As Downey and Lucena have pointed out "engineering education has gained particular salience in these developments because engineers figure as key participants in virtually every image of increased national productivity" (2007, p. 121). They go on to say that "engineering education is widely understood not only as a place where good students prepare themselves for career tracks that promise financial stability and upward mobility but also as a test site for the refiguring of patriotism. Research that seeks participation in the fashioning of engineering selves risks contributing to this nationalistic fervour by improving students' abilities to purse the goals of competitiveness without critically examining its contents" (Downey and Lucena 2007, p. 123).

Clearly these 'thought styles' are not hegemonic in the sense that all engineers conform to the dominant ethos; after all, Gramsci himself was interested in the possibility of resistance to cultural forms of domination and control. Not all engineers accept that the purpose of their work is to maintain the status quo within their own society. Many choose not to participate in mainstream corporations because it does not accord with their personal values. Matt, for example, graduated as an aerospace engineer but moved away from that field because he "didn't see it as having much benefit to the world". He now works in the civil, environmental and energy fields. For a while, he worked for a private company which supplies essential services (power, water and sewerage) to remote Indigenous communities in the north of

Western Australia. The provision of these services is difficult and complex. The 'difficulty' is due to physical isolation and hot, dry weather conditions which require innovative technical solutions, while the 'complexity' arises from negotiating the legislation, government bureaucracy and funding systems which conspire against the delivery of services to which Aboriginal people are entitled. While learning about these political issues was a challenge, he also says that an outstanding feature of his work was learning about Indigenous knowledge and culture. Like most engineers, he did not have the opportunity to learn about such matters during his undergraduate career. Nor are engineers – or anthropologists – educated about the process of democratic government which may stifle the implementation of even the most innovative solution to an existing inequality.

The opportunity to learn about these issues clearly exists in the workplace but the desire to take these opportunities ultimately rests on personal values and individual beliefs. We argue that transformation needs to take place – not just at the individual level – but within and between disciplines for social change to occur. It is difficult for all of us to work against the all-encompassing, totalizing view of economic life in our own society if we cannot imagine what, if any, alternatives exist. We further argue that it is particularly difficult, or troublesome, for engineers because they are not encouraged, or do not have the opportunity, to be self-reflexive or critically engaged within current engineering curricula. This chapter suggests ways we can help students question the tacit thought styles of engineering knowledge and practice, so that they are better able to pass through conceptual thresholds which will assist them in a critical understanding of the relationship between engineering practice and structures of inequality. The interdisciplinary framework which we have used – both in the critical questioning of tacit knowledge, and the identification of threshold concepts – is crucial to this endeavour. If we do not work with other disciplines, we cannot reshape engineering education to facilitate students' understanding of how inequality comes about and then to further realize that these inequities are historically and culturally specific.

In previous work we have called the necessary interdisciplinary conversations 'knowledge negotiation' (Baillie 2002). For our current work we have been negotiating knowledge within a large interdisciplinary team on the topic of 'Engineering for Social and Environmental Justice' in which we research appropriate curricula and pedagogies for embedding in and transforming engineering programs. Knowledge negotiation and mapping formed the initial part of the project and is the focus of this chapter; it is supported by an multidisciplinary team with representatives from engineering and education together with history, environmental history, Asian studies, anthropology, philosophy, Indigenous studies, Law and Science and Technology studies.

This team was asked to consider a range of questions to inform the critique of current practices as well as to develop a knowledge base for the socially and environmentally just engineer. They were asked to bring to the table key ideas, authors, texts and ways of thinking from their discipline, which would enable us to begin to answer our queries about the role of engineering in future society. We used *threshold concept theory* to interrogate how and why these concepts could be useful for engineering knowledge. This is discussed more fully below but, briefly, we focused explicitly on the *thresholds* which seem transformatory in each contributing discipline by asking 'What are the key transformatory concepts which students of your discipline need to understand which might help engineering students enter into your disciplinary way of thinking?'

The emergence of knowledge about thresholds, however, did not only come from within the disciplines but between the disciplines. In this case we might ask 'What concepts appear at the boundaries of social science disciplines as they interface with engineering?' These emerged as the team – itself representing many disciplines, scrambled to understand one another and to communicate their ideas. Whose theoretical framework, methodology and writing styles do we adopt and how can we structure a conversation about engineering and social justice when we have different underlying assumptions about knowledge?

7.1.2 Theoretical and Methodological Framework

Our adopted theoretical educational framework is Threshold Concept Theory (TCT). The idea of *threshold concepts* was developed in the UK by Jan Meyer, Ray Land, and others who realised that there were certain concepts, central to a discipline, that would open up required systems and ways of thinking and practicing, yet were troublesome for many students (e.g. Meyer and Land 2005; Meyer et al. 2010). Threshold concepts have been described by many as a sort of *portal* or gateway through which students can pass – and if they do, they emerge with new ways of seeing, and furthermore, new areas of knowledge are opened up to them. Other students however, become stuck and are unable to pass through this gateway. They become disillusioned and often take up surface approaches to learning which mimic what other students are doing. Meyer and Land suggest that the threshold concepts are likely to be *transformative* i.e. that they mark a shift in the perception of the subject by the student, *irreversible, integrative, bounded* and *troublesome.* The latter draws on Perkin's (1999) perceptions of *troublesome knowledge*:

1. *Ritual knowledge* – routine and rather meaningless character such as following procedures in arithmetic. In an attempt to make a concept seem more understandable, teachers sometimes create a naïve version of the concept and students enter into a form of ritualised learning or mimicry. When the students show no signs of understanding the concept teachers simply ask them to do more of the same. This can seem very dull to students who often describe learning in these areas as boring.
2. *Inert knowledge* – not integrative nor seemingly related to real life. Integration is troublesome because students need the 'bits' before they can be integrated but after this they need to be persuaded to see the whole in a new way. Hence often new knowledge remains as disconnected pieces which are therefore void of life.

3. *Conceptually difficult* – what we often notice as teachers is that in an attempt to learn difficult concepts, students mix ‘expert’ views of the concept with their own misconceptions. Often the intuitive belief resurfaces in any other context than the exam room.
4. *Alien knowledge* – knowledge can often be counter intuitive, e.g. the notion of objects in motion, asking students whether heavier objects will fall at the same rate as lighter ones will often result in confusion.
5. *Tacit knowledge* – understandings are often shared between a community of practice but not often explained or exposed e.g. a person coming into a new community or country may not pick up the nuances of different concepts which are ‘common sense’ to the old-timers.
6. *Troublesome language* – discourses have developed within disciplines to represent ways of seeing – but these can be troublesome for the newcomer especially if the words have a common usage as well e.g. ‘elasticity’. The problem we have is that no concepts can exist outside the system of thought and language. It is entirely possible that a concept can be understood on one way in one country (or discipline etc.) and very differently in another for this reason.

Meyer and Land suggest that where difficulties exist, the learners may be left in a state of *liminality* (Latin ‘limen’ – a threshold). Liminality may refer to an individual or a group – a suspended state in which understanding approximates to a kind of mimicry. The transition is problematic, troubling and often humbling, and students often mimic the new status without understanding the meaning of what they are doing. They may oscillate back and forth but once entered the student cannot return to the *pre- liminal* state. This is compared by Meyer and Land to cultural initiations or to adolescence, however in education as with other contexts, it is clear that students may not reach the transformed status and become stuck. Thus we could understand that dysfunctional development of a child who does not enter adulthood is similar to the dysfunctional learning of a student who attempts to mimic the conceptual understanding and may have some preliminary grasp but is only interested in reproduction (i.e. as with the ‘surface approaches’ described earlier).

A survey of first year engineering students at the University of Western Australia (enrolled in a unit co-designed by Armstrong and Baillie) revealed these different kinds of knowledge at work (Parkinson 2011). Lateral thinking, for example, is troublesome to students because it was seen as ‘foreign, ‘inert’ and ‘conceptually difficult. When asked to consider how best to solve apparently intractable problems such as ‘poverty in Africa’, students have to “think beyond maths and science” (Parkinson 2011, p. 29). A common response to this problem was: educate more engineers. When pushed to consider other solutions to complex issues, one students said “that solving world issues or issues not in my context, is a lot more complicated than it appears’”! (Parkinson 2011, p. 30).

In order to shed light on tacit ways of thinking we focused on threshold concepts which might appear from within the social science disciplines or between the social and natural sciences and which might prove troublesome for engineering students to understand – to pass through the threshold.

7.2 Thresholds at the Boundaries of Disciplines

We have so far discussed how best to dismantle, or at least question, the world-views of engineering students and graduates. What we will do here is consider how to create a dialogue between different disciplinary world-views. Through previous work on knowledge building in multidisciplinary settings it has been shown that conversations between scholars of different disciplines could open up the potential critical or threshold concepts within a discourse by querying what for one scholar seemed 'common sense' but was not for the other (Baillie 2002). Baillie (2002) has studied this form of knowledge 'negotiation' by focusing on interdisciplinary conversations between students and researchers, to uncover the patterns of how knowledge is negotiated across that interdisciplinary space. She considered barriers to this knowledge building, and looked at pathways that could help us across these barriers and what evidence existed that showed that passageway through the barrier had taken place. These findings are set out in Table 7.1 (Baillie 2002).

Interdisciplinary knowledge negotiation can enable students to move beyond the barriers (1–7 above). Pedagogical approaches within these interdisciplinary settings can develop pathways to question attitudes and evoke conversation (8 and 9 above) and assessment methods can be tailored towards ascertaining if students have indeed changed in their ways of knowing and seeing (10–15 above). Moving a student through a threshold, of seeing through the lens of social justice gives clear examples of each of these (Kabo and Baillie 2010). Questions, not from a lay person or a novice but from another scholar intent on working on the same issue but possessing a very different 'thought collective', will be critical, incisive, and will,

Table 7.1 Factors affecting the knowledge building process (Baillie 2002)

Barriers to knowledge building
1. Power relations
2. Thought collectives
3. Objectification
4. Social structures
5. Blinkered perception
6. Negative environment
7. Belief system
Pathways through the barriers
8.Attitude – Humility, empathy, interest
9.Conversation – Refutations, questions, avoiding avoidances,
Evidence of knowledge building
10. Thinking about knowing
11. Differentiating between surface and depth
12. Inclusive value systems
13. Identification of basic concepts
14. Change in world view (seeing the world with new eyes)
15. Euphoria

we hypothesise, highlight these thresholds. We therefore asked engineers and non-engineers in our research team to collaborate and interrogate keywords, 'threshold concepts' and ways of thinking in their discipline and which arose as they conversed.

7.3 Mapping Threshold Concepts

Scholars from engineering, history, law, anthropology, philosophy and Indigenous studies identified a range of key concepts, arranged into broad themes, which they considered critical for engineering students to embrace.

Each of these concepts has the potential of being a 'threshold concept', that is a critical concept which is likely to be transformatory and 'troublesome'. There are other defining aspects of threshold concepts currently debated by the community such as 'bounded', 'integrative' and 'recursive' but the former two qualities are never in question so we have used these as preliminary indicators in our study. Each team member identified those concepts which they have found to be transformatory and often troublesome for students within their own discipline and therefore are considered to be even more so for engineering students. It is of course also necessary to test this on engineering students, to see if these are indeed threshold for them and this will be done in the next stage of our project. The initial work to identify thresholds in curriculum is often done by the teachers of a subject, who identify areas which students need to know but have trouble with and also by students who will be able to identify the latter. This knowledge is then tested by the disciplinary community – as has been done by economics and computer science (and biology to a degree) disciplines to date. As the work on threshold concepts is still relatively young (about 9 years), many aspects are still being questioned and debated, both theoretically and methodologically. The resulting concepts may be seen in Table 7.2.

It would be useful at this point to illustrate what we mean by the 'troublesome' component of some of these key concepts tabled below.

We have argued elsewhere that understanding difference needs to go beyond demonstrating that the seemingly strange or irrational makes sense when placed in its proper context (Armstrong and Baillie 2012). What we will do here is demonstrate how a full understanding of this concept goes, as Ingold describes it, to the "heart of some of the most basic presuppositions of Western thought itself" (1994, p. ix). When we ask students to consider the inequity which is inherent in the flows of labour and capital around the world, we are in effect asking them to critique dominant economic and cultural values and to consider that there might be meaningful, and more just, alternatives. It is challenging for all students – engineers and non-engineers alike – to achieve this kind of understanding.

The first year engineering unit at the University of Western Australia, "Global Challenges in Engineering" is designed to encourage students to question basic taxonomies of knowledge. There are no lectures; students attend two workshops

Table 7.2 Keywords considered to be critical and potentially threshold for engineering students

Questioning epistemologies	Understanding colonialism	Questioning progress	Understanding capitalism	Understanding difference	Understanding power
Indigenous knowledge systems	Empire	Industrialization	Commodification	Culture	Inequality; class
Dominant scientific paradigms	Post-colonialism	Modernization	Alienation; labour	Masculinities	Subaltern
Objectivity	Development, charity, aid	Modernity	Neoliberalism	Gender	Racism
Neutrality	Post-development theory			Identity	

where they are expected to 7.2 debate the different meanings attached to concepts such as ‘globalisation‘, ‘difference’, ‘poverty’, ‘development’, ‘ethics’ and ‘justice’. These are not abstract discussions; students are presented with real life problems which set out the incontrovertible effects of neoliberal capitalism.

The students response to this diverse; some comment that it takes them beyond their comfort zone while others wonder why are were talking about such issues at all. In one session, for example, we ask students to consider the effects of corporate takeovers on factory workers by reading firsthand accounts of being sacked under the guise of “downsizing” (Lambert 2004). Students take on the roles of board members in Sweden, management in Australia, and is the workers on the factory floor. We ask students to consider what other kinds of economic organization might be possible, and how might they behave if – as is very likely – they are asked to ‘cut costs’ and ‘ensure growth’ by sacking the people they have been reading about.

Many students’ perceptions changed as a result. One student said, for example, that “I have learned how to look at the complete impact that a produce we consume can have on the world, such as where it came from, how it was produced, people affected by the production of this product” (Parkinson 2011, p. 40). Yet even though students may be sympathetic to the plight of workers who have been sacked, many feel there is no alternative to capitalism. It is common to hear students say that it is ‘human nature’ to maximize profits at all costs. Questioning dominant economic paradigms is difficult for all university students, regardless of their degree. It is particularly difficult for engineering students who are more likely to be locked into the dominant discourse about maximization of profits, and the link between technological innovation and profitability.

This illustrates the concept of *‘tacit’ knowledge* which we mentioned earlier. It is the tacit way of thinking of engineers, and also often their parents, which the students have internalized and have difficulties then knowing how to begin to question the assumptions they have made. When students were asked to consider alternatives to capitalism, the reactions ranged from interest to confusion or outright hostility. This may reflect the demographic of students at the University of Western Australia which is mainly white and middle class but even the minority of migrant, working class students often see these debates as a hindrance to their aspirations for wealth and prosperity.

With such a wide range of views, it is not surprising that students became very involved and quite heated in debates about the impact of globalization. One tutor explained that

> After we’d had our little meeting and stuff I thought they’re not really going to get into it or anything and I’m not sure some of them understood the concepts. By the end of it all we had this full on debate and people were taking sides around the room and they were so passionate and that that activity where they had to be part of the Brunswick factory… it was wonderful and that was probably one of the best workshops we had because they all got excited. Whatever side they picked I asked everyone to give me a reason.

In another section of the course, we ask students to consider ‘ethics’ and ‘justice’ within a framework of neoliberal capitalism. Students are expected to critically appraise the Engineers Australia Code of Ethics and debate whether it has relevance to engineering practice. We provide them with a contemporary narrative about a transnational mining corporation in Papua New Guinea where security forces have been responsible for sexual assault of local women, and also where local people sift through mine tailings for pieces of rock which are then treated with mercury to access any gold which may be present (Waters 2011). Students are shocked by this story but find it difficult to see what engineers can do about such injustices. Again we see many tacit assumptions at work: about engineering practice (“we have to do what we are told”); or about values (“people won’t speak out if they want to keep their job”).

This brief outline of the learning experience which leads to an understanding of inequality and injustice reveals that it is ‘troublesome’ precisely because it based on the realization that there are different knowledge systems and epistemologies beyond a dominant discourse which perpetuates inequalities across cultures. Understanding difference is a key theme which runs through this first year unit and it is interesting that student’s reactions are contradictory. One the one hand they appear to struggle – “I’m confused” is the most common phrase in student feedback – yet their response to the learning experience is overwhelmingly positive.

Overall, there is a process of knowledge building (see Table 7.2) in this unit albeit not always a smooth or easy process. We begin to see students shifting in their explanations of why inequalities exist and that there are many different reasons for inequality and many solutions to it. The key goal here is not just to use the explanatory potential of social theory and to understand that there are “different ways of perceiving the world, but (that there are) …different ways of imagining what life ought to be like” (Graeber 2001, pp. 21–22).

Another classic area of troublesome knowledge for science and engineering students is the myth of objectivity in Western science– that there is one truth about the world which they will discover if they only search long enough. Physicists since Einstein have had to address multiply correct conceptions and yet due to the lack of language or discourse to describe this odd phenomenon would mostly suggest if interrogated that multiply correct answers represent only a partial understanding of reality. This has been misinterpreted by philosophers of science as being the same as scientists believing in objectivity. In fact their practice is very different from this. Practitioners do not behave as if there was one truth and their papers include much argumentation and interpretation – they simply don't have the language to describe this uncertainty. When faced with social issues where the uncertainty and lack of clearly evident ‘solution’ to problems it is common for engineering students to dismiss the knowledge as ‘soft’ and learning anything with such a lack of clarity as a waste of time. It is *counter intuitive* for students who have been brought up to locate the right answer – to then be told to formulate a position.

This has several implications for engineering students in their journey towards critical thinking. The first has been mentioned above: that is, the realization that there is no one 'solution' to the problems of inequality and injustice. When asked what the students found most challenging, one tutor explained:

> The fact that they didn't know exactly what they had to learn. They're not very good at interpreting what we said but also they are simply used to a science subject where it's very clear and they learn this formula and apply it and do this practice problem whereas this was a real life problem without any correct answer and the fact that there is no real answer and specific things I think it was quite difficult

Students also find it difficult to accept anything other than empirical facts as evidence for the existence of a problem which requires a solution. Second year students at the University of Western Australia were asked to critically analyse alternative sources of energy with a social justice lens; in their preliminary analysis of the effect of wind turbines, it was clear that they were dismissive of subjective statements made by farming communities about the effect of the noise on their health. Downplaying the health costs of development is a common problem, particularly in the mining sector (e.g. Brueckner and Ross 2010) and students are asked, not just whether it is possible to be 'objective, value-free and scientific' but to what extent self-interest drives these positivist attributes. They are introduced to different knowledge systems, and also asked to question notions of 'scientific expertise' which often assume there to be one basic truth known by the experts.

7.4 Thought Styles Within and Between Disciplines - Anthropology and Engineering

Teaching self-reflexivity within engineering is necessarily based on an interdisciplinary dialogue. "Interdisciplinarity", however, often refers to collaboration between disciplines that are not too dissimilar: anthropology and human geography, for example, or between different schools of engineering. Collaboration between the humanities and engineering is rare because the intellectual paradigms are so different. An engineering student who looks at the keywords in Table 7.2 would justifiably feel as if they were in unfamiliar territory, quite at odds with the positivist world of engineering education. To exemplify this we discuss here the meeting of anthropology with engineering.

On the surface engineering and anthropology could not be more different: anthropologists question while engineers solve. Anthropologists, for example, spend a great deal of time trying to "discern what taken-for-granted terms…might mean" (Comaroff 2010, p. 533) and this makes interdisciplinary work – even with other humanities disciplines such as economics or political science, quite challenging. Djohari, an Anthropology lecturer who also teaches students in Development and Medicine in the UK, says that "As anthropologists we revel in self-criticism and questioning. Shedding light on preconceptions is perhaps the greatest joy anthropology offers – a moment of revelation: showing something considered complex to be simple; something thought obvious to be intricate; and practices seen as ‗normal suddenly appearing alien. We enjoy this revelatory moment as much, if not more, when it is focused on our own discipline. Sharing this with our students can be hugely gratifying. But this joy is not necessarily transferable if it appears as ‗us' (Anthropology), criticizing ‗'them'…." (2011, p. 27). She goes on to say that "In anthropology, my experience of teaching is that we offer many critical courses, but stop short of going on to show how our critical, self reflective content can have a positive application in 'the real world'" (Djohari 2011, p. 27).

This sentiment is shared by Monica Minnegal, an anthropologist who works with environmental scientists, and who has written about the possibility of a dialogue between the two disciplines. She too says it is time "to move beyond assertions that anthropologists have important insights to offer both environmental management and science and address the nature of barriers to communicating those insights. For anthropologists, this means they have to reflect on themselves as a discipline and on how they can productively interact with scientists or, indeed, engineers" (2005, p. 3). Minnegal feels these are complementary, rather than contradictory, approaches and asks whether we can "re-frame our questions in terms of language and concepts that are more familiar to those with whom we are seeking to communicate?" (2005, p. 2). We have discussed, very briefly, how this questioning *can* be introduced into engineering education. But how can an understanding of engineering practice shape anthropological knowledge? While it is true that engineers have much to learn from anthropologists (in their ways of questioning their own common sense and values, and understanding other cultures and epistemologies) so too anthropologists can learn from engineers. There is a significant gap in anthropological knowledge about what engineering entails or how engineers work except for a very few examples (see Downey 1998). Only a few anthropologists, generally those working as consultants in the resource sector, work in dialogue with other disciplines. Martha Macintyre, for example, works with mining companies in Papua New Guinea, and has reflected on how this experience has challenged academic ways of thinking. She says that "working as a consultant on a variety of projects has provided me with the opportunities to work cross-culturally within Papua New Guinea that would have been impossible had I remained an 'academic' researcher. My experiences in towns, villages, mine sites, police stations, hospitals … sometimes made me dismissive of the arcane arguments of my discipline" (Macintyre 2001, p. 08).

Clearly situations arise where our conventionally held beliefs – as engineers or anthropologists – are challenged. We would argue, however, that the likelihood of these challenges being embraced is unpredictable and likely to occur despite, not because of, the teaching and learning within conventional curricula. We also believe that while personal values and life experience may compel some engineers to question equity and justice in the workplace, it is nonetheless imperative to equip all graduates with the critical thinking skills and types of knowledge we have been discussing so far. This kind of interdisciplinary conversation is not easy and involves passing through the above mentioned thresholds. What follows is a narrative of a dialogue between an engineer and an anthropologist focusing on 'why culture matters' to engineering practice. The outcome of that conversation has been published elsewhere (Armstrong and Baillie 2012) but we look here at some of the bumps and hurdles encountered on the journey to illustrate that such a dialogue is not just possible, but essential if we are to transform ourselves and others in understanding and addressing social inequality within engineering education.

> Rita, anthropologist, took the pen first. When I, Caroline, engineer and engineering educator began to respond, I found the paper hard to follow. It was not that the language was troublesome, nor that there were several other thresholds concepts as above blocking me, as I have been working with social justice for several years now. However, the arguments seemed very 'internal' to the discipline of anthropology. Rita was arguing for cultural relativism, not from the perspective, as above, of the engineer who might otherwise think that it meant, simply, appreciating that others are different from me, relatively speaking, but as if her audience were anthropologists of a different school of thought. She was arguing from a historical viewpoint about the development of cultural relativism but in ways that were unfamiliar and therefore inaccessible to me. This was so similar to some of the conversations with historians and economists I had encountered during my former work on knowledge negotiation, that I recognized it as 'thinking within the discipline' or within a 'thought collective'. Instead of getting defensive and thinking – this is poor writing because I don't understand it, I went to Rita and asked if she could write as if explaining the concept to engineers, or indeed, to me. The whole style transformed and the process became much easier after that. Even though I thought I understood notions of deconstruction and questioning assumptions, I had been assuming a simplistic definition of cultural relativism…. (Caroline)
>
> When Caroline asked me to write the initial draft on why, or how, cultural relativism would be a useful concept to bring into engineering education, I, Rita, wasn't quite sure who I was writing for. I had attended an "Engineering and Social Justice" unit run by Caroline in which students were asked to examine engineering stereotypes and to consider what they 'said' about the discipline (see Riley 2008). However I wasn't familiar with these representations and the few academic engineers I met since joining the Faculty of Engineering were far removed from those archetypes. Imagining I was addressed a group of (probably academic) engineers, I decided I needed to explain 'the history of cultural relativism' before outlining the complexities of such a concept. I was, as ridiculous as it now seems, trying to condense several lectures (for anthropology students) into one digestible piece for engineering practitioners. No wonder it didn't speak to engineers jumping as it did from human rights in the 1940s to epistemological relativism in the 21st century. Caroline asked me to try writing for her; by then I had also interviewed some engineers for another project of ours, so I decided to write for those engineers as well (who work with Indigenous people on mine sites). Writing for a real, rather than an imaginary audience, made the task both easier and more challenging. While I retained aspects of my abstract 'guide' to the meaning of cultural relativism, I also tried to create a dialogue which opened up debate and posed questions; using narratives about the experience of anthropologists like Martha Macintyre working with engineers on mine sites in Papua New Guinea, for example, illustrated how it can be both a powerful tool for understanding as well as a challenging and slippery concept. (Rita)

The possibility of a dialogue between engineering and anthropology is a useful example of how it may be difficult, but nonetheless possible, to cross disciplinary boundaries and face key thresholds. We acknowledge that the whole notion of 'disciplines' as they are constituted in universities are historical constructions and the boundaries between them may no longer be relevant (Wallerstein 2003). Disciplines are not, as Wallerstein says, homogenous: anthropology is not a unified discipline and engineering itself covers many diverse kinds of knowledge and practice. Nonetheless, the labels which we have used to typify each discipline – reiterated below – are a useful shorthand to describe the dominant 'thought style' of each. By doing so, the two authors were able to uncover and make more explicit some of the inherent assumptions behind the threshold concepts which students would need to understand in order to grasp the complexities of social justice.

7.5 Summary

In our experience of interdisciplinary teaching contexts, where social science and engineering students study the subject of 'Engineering and Social Justice' together – we find that the former transform their beliefs and thought styles just as much as the engineering students. Kabo and Baillie (2010, forthcoming 2012) have studied the passageway of both engineering and social science students through the thresholds of this course. Engineering students found the course troublesome as it questioned preconceived notions of society, whereas social science students were forced to question their preconceived notions of what engineering was and could be. A further and very noticeable difference was the predominant 'ways of thinking', that these students had either brought with them or developed during their first years of study. Engineering students classically solve problems, whereas social science students ask questions. More importantly – social science students 'deconstruct' knowledge, thoughts, actions, objects – anything they can get their hands on. And engineers build. Bringing these two thought patterns together, demonstrated to us as teachers that the combination of deconstruction and 're-construction' of alternatives, is necessary to build a better society. Thus, in the course we asked engineering students to question everything and we asked social science students to stop questioning and to start creating. It was just as difficult for the latter to build new thoughts about potential futures as it was for the engineering students to stop having old ones.

When writing against the need of the West to 'save' others, Lila Abu-Lughod asks

> …how we might contribute to making the world a more just place, A world not organized around strategic military and economic demands; a place where certain kinds of forces and values that we may still consider important could have an appeal and where there is the peace necessary for discussions, debates, and transformations to occur within communities, We need to ask ourselves what kinds of world conditions we could contribute to making such that popular desires will not be overdetermined by an overwhelming sense of helplessness in the face of forms of global injustice, where we seek to be active in the affairs of distant places, can we do so in the spirit of support for those within those communities whose goals are to make women's (and men's) lives better …Can we use a more egalitarian language of alliances, coalitions, and solidarity, instead of salvation? (2002, p. 789).

That ‘egalitarian language’, however, must also be comprehensible across disciplines. In ‘negotiating’ interdisciplinary transformative knowledge, we acknowledge earlier calls for us to pay attention to the idea that knowledge is not a fact; it is created purposively with the intention of shaping individuals and communities (e.g. Carr and Kemmis 1986; hooks 1994). If we are more open and questioning of our own thought processes and assumptions, albeit that these are different assumptions to those of our different disciplinary neighbours, then we will begin to help each other move across seemingly insurmountable thresholds. We will move into a liminal space where we ask each other questions in order to co-create our future.

This project has been an explicit attempt to start knowledge negotiation between scholars, around topics related to engineering and social justice. In doing so we have identified key threshold concepts for students to learn, as well as important ways of thinking which help us to solve the larger problems of the world, and which also support the passageway of students through the thresholds.

There are at least three strategies which we would recommend, in supporting students to pass through these interdisciplinary thresholds – along the pathway towards social justice:

1. Creating opportunities for students to learn in interdisciplinary settings, not just where the topics are interdisciplinary but where the students are a mixed cohort of natural and social sciences and where possible the class is co-taught, will enable us to support students on their liminal journeys. Seeing the course lecturers question each other’s assumptions and admitting ignorance, before the students, has been found by our team to be the most effective approach in supporting students to question themselves and admit their own lack of knowledge and willingness to learn new ideas.
2. Explicitly focusing students’ attention on threshold concepts that we have already identified, such as those in Table 7.2 above. The course may be designed with this in mind – allowing more time for concepts known to be troublesome. Students need to engage, debate, and work with these concepts. Focusing on threshold concepts would be a marked difference compared with the way many existing engineering courses are run that intend to help students consider the social or ethical consequences of their work. Creating a course which is taught in a traditional way, with lectures ‘about a social context’ will not shift mind sets, ways of thinking, or enable the questioning of assumptions. Only critical thinking will facilitate the students to transform their worldviews and to start to embrace the tricky, troublesome and yet critically important threshold concepts we have identified above.
3. Engaging scholars from different disciplines in the design, as well as the teaching, process and who are prepared to be critically reflexive about the dominant discourse within their own disciplines.

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Chapter 8
Connecting the "Forgotten": Transportation Engineering, Poverty, and Social Justice in Sun Valley, Colorado

Jen Schneider and Junko Munakata-Marr

> *Yet [Sun Valley] has persisted. Out of neglect. Or the lack of resources and political will. It persists because Sun Valley represents in pure form the daunting legacy of social and economic segregation and the challenge of providing economic and educational opportunity to the neediest among us.*
>
> –Tina Griego, *The Denver Post*, 2010

> *The light rail stop at this location would be creating a means for companies to move into the community and the Sun Valley residents should not be forgotten when serving the area is concerned…the permanent residents of this area must not be forgotten.*
>
> –Student, Sustainable Engineering Design, 2011

Abstract This chapter explores the role that transportation engineering, economic planning, and community engagement play in the development of a lightrail system station in Sun Valley, Colorado, one of the poorest neighborhoods in the state. It describes how such a case can be used to teach principles of social justice, sustainable community development and sustainable engineering in the undergraduate engineering classroom. Students in the course "Sustainable Engineering Design" at the Colorado School of Mines were asked to study the Sun Valley community,

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meet with members of the community, and study the lightrail project not only as a sustainability project but as one with significant social justice dimensions. This chapter examines the challenges and rewards of integrating engineering and the social sciences in this kind of real-world context, emphasizing the importance of integrating Cech's critiques of depoliticization and meritocracy in engineering culture.

Keywords Engineering and sustainability • Engineering and development • Transportation development • Engineering education

8.1 Introduction

This chapter describes a particular curricular intervention that was inspired by research in engineering and social justice (ESJ). Students in a Sustainable Engineering Design (SED) course were introduced to a case study describing an actual neighborhood in Denver, Colorado, that is known primarily for its poverty, high rate of single-parent households, and lack of access to jobs and services (City Data: Sun Valley Neighborhood 2009; Griego 2010). The neighborhood, Sun Valley, is located near downtown Denver and the Denver Broncos football stadium, yet is also physically isolated from abutting neighborhoods and city infrastructure. Furthermore, we would wager that very few residents of Denver and its environs even know that Sun Valley exists, leading some residents to describe themselves as the "forgotten" (Griego 2010). Students who participated in this curricular intervention in SED examined the development of a lightrail line through Denver's West Corridor, including a transit stop that would link Sun Valley with the line, and which promises to bring significant economic and social changes to the neighborhood. Students in SED were given a series of newspaper articles about Sun Valley, read planning documents about the lightrail station project, met a former resident of the neighborhood, and were guided through several exercises about the case in an effort to encourage them to think critically about sustainable development processes and goals as well as the strengths and limitations of life cycle analysis software frequently used by engineers involved in planning and decision making. We describe below the outcomes of this intervention.

This chapter is not intended to be a rigorous engineering education study; the SED curricular intervention was a small and preliminary experiment, and we do not make claims about its scalability or applicability in wider contexts. Rather, we see this chapter as a reflection on how we envision engineering and social justice as a concept; as an example of how one might meaningfully integrate social justice into engineering courses whose primary focus is technical; and as a discussion of how we can better make "cultural space," in Erin A. Cech's words (Chap. 4, in this volume), for social justice in teaching engineering. One of us—Jen, whose academic fields are communication and engineering education—has worked on collaborative projects that examine whether engineering and social justice may or may not be "commensurable" as concepts, particularly in an engineering curriculum that frequently is resistant to change (Leydens et al. 2012; McKenna et al. 2011). A nagging, unresolved question that has persisted from that work is as follows: it is fairly easy to imagine how social justice might be integrated into humanities and social sciences courses for engineers, and even in multidisciplinary design courses (see Chap. 9 by Leydens, in this volume). But how do we integrate social justice as a concept into technical courses, particularly those which stress engineering science, and which occupy most of our students' time, attention, and even respect (Downey and Lucena 2003; Lucena et al. 2010)? In posing this question, we hope to enter into dialogue with Erin A. Cech's chapter in this volume, titled "The (Mis)Framing of Social Justice: Why Ideologies of Depoliticization and Meritocracy Hinder Engineers' Ability to Think About Social Justice." In that chapter, Cech calls on engineering educators to make "cultural space" for social justice in the engineering curriculum by inviting students to analyze and reflect on two main characteristics of engineering culture—depoliticization and meritocracy—that tend to exclude critical appraisals of social justice in engineering work. Although we did not have the benefit of reading Cech's work when planning our intervention, in this chapter, we reflect on the ways in which that small intervention made cultural space for exposing and analyzing depoliticization and meritocracy, and ways in which we could have done this important work better.

Possibilities for integrating social justice concerns more meaningfully into the parts of the engineering curriculum typically considered "technical" are many and varied, and other scholars are beginning to provide practical examples of how real implementation in the technical curriculum might work (see Chap. 3 by Riley, this volume). Junko, a professor in environmental engineering, has taught a number of technical courses that meet curricular needs but which also experiment with teaching and learning innovations. Her openness and willingness in this regard was essential to moving forward with this experiment. With Jen, Junko participated in a 2-day workshop on ESJ, and has been committed to seeing what ESJ might look like in practice inside of an engineering course. We offer the narrative of our collaboration here. It is our hope that sharing this story might illustrate ways in which other engineering faculty members could create spaces, and collaborate with non-engineering faculty, to experiment with social justice concepts in their own courses.

8.2 ESJ in Engineering Education: The Practical Problem

Compared with 10 years ago, a relative wealth of scholarship is available about engineering and social justice (see Chap. 2 by Nieusma, in this volume). This is in large part thanks to the work of scholars in the Engineering, Social Justice, and Peace network (ESJP; www.esjp.org). Caroline Baillie and George Catalano have made foundational contributions in introducing the connections between engineering and social justice in their books *Engineering and Society: Working Toward Social Justice*, Parts 1–3 (2009a, b, c) in addition to their other work in this area.

Donna M. Riley's book, *Engineering and Social Justice* (2008) proposed critical approaches to thinking about persistent conceptual questions such as how to define social justice, how engineering universities, firms, and other organizations may be structurally aligned—even if sometimes unintentionally so—to support unjust engineering practices, and how a number of "engineering mindsets" shape the ideology of engineering and might blind engineers to see social injustices. Riley has since authored a textbook integrating ESJ and thermodynamics (2011) and has co-edited a volume with Caroline Baillie and Alice Pawley on ESJ in the university (2012). These authors and others highlight the challenges engineers and engineering educators face in their efforts to bring their professional practice in line with social justice values (Nieusma and Riley 2010; Schneider 2010).

This last area of study—how social justice concepts can be mobilized to intervene in and change the engineering curriculum—is of most interest for this chapter.[1] Despite the significant efforts of the scholars listed above and others, just *how* to incorporate social justice into engineering education and practice remains a very open question. For example, in 2011, Jen worked on an informal video project about teaching ESJ, and asked seven ESJ-committed engineering instructors to provide videotaped narratives describing where their social justice concerns came from and how they changed their teaching to include them (see http://www.youtube.com/watch?v=LbE_AaquL5E). The goal of the video was not to identify humanities and social sciences courses where social justice could be incorporated, but to understand how engineering practices and education might intersect with social justice in the "technical" classroom.[2] Several possibilities for in-class implementation of ESJ emerged, but can primarily be grouped into three categories:

1. interventions that incorporate transformational pedagogical approaches, frequently incorporating concepts first introduced by Paulo Freire and bell hooks but not limited to those (e.g., Baillie 2006; Meyer et al. 2010; Chap. 3 by Riley, this volume);
2. service learning and engineering for development projects (e.g., the work done by EPICS at Purdue and projects taken on by Engineers Without Borders); and

[1] This chapter would have benefitted from a review of the work included in the new collection *Engineering and Social Justice: In the University and Beyond*, edited by Caroline Baillie, Alice L. Pawley, and Donna M. Riley (Purdue University Press: 2012), which was not yet available for review at the time of this writing.

[2] STS scholars and others are quick to point out that it is quite artificial to distinguish between the "technical" and "non-technical" in engineering practice and education. Technical decisions are always informed by and situated in social, economic, political, and other contexts, and vice versa. However, we keep this distinction in place for the purposes of this paper merely to mark the distinction between courses that, at our university, are considered humanities and social science courses, and those that are considered engineering or applied sciences courses. Though we and others work hard to trouble this binary, it is nonetheless descriptive of many of our students' experiences with the engineering curriculum and is further reified by curricular structure, professors' expectations, and so on.

3. revision of existing technical curricula to include perspectives or approaches typically excluded from the engineering education canon (such as Riley's supplementary thermodynamics text, mentioned above, or the rewriting of typical engineering problem set questions to include more social justice-oriented contexts or topics).

This typology can be debated, but we would argue that most practical attempts at intervention fall into one of these categories, with the most frequent being efforts in the second category, service learning and engineering for development projects. The fact that many efforts that fall under the umbrella of "engineering and social justice" are typically development projects is somewhat troubling given the fact that such projects are difficult to execute and evaluate successfully and, in some cases, may even unintentionally exacerbate injustices (Schneider et al. 2009). Furthermore, all three types of integration in our list seem to require significant commitments to mastering "outside" types of knowledge, training in critical thinking skills, humanities, or social science literature approaches, and risk-taking in curriculum design. It is not inconsequential, for example, to ask an engineering professor to become trained in Freire's techniques from the "theater of the oppressed" or to design a meaningful service-learning project that benefits both students and the host community of the project. For these reasons and others, inviting even interested and sympathetic engineering educators not steeped in the literature of social justice to incorporate social justice principles in their courses—without requiring that they master an entirely new body of literature or fight to revamp the entire curriculum—remains a major challenge. University faculty face significant time pressures and a reward system that often does not recognize these interdisciplinary adventures, while technical faculty take a risk when they study, publish, or teach outside their areas of technical expertise. The barriers to inclusion in ESJ, even for those who are ready and willing, are not insignificant (Leydens et al., (2012); Chap. 3 by Riley, this volume).

Nonetheless, many engineering faculty *are* committed to and interested in incorporating ESJ practices into their classrooms, and are craving more information about *how* to do this. In 2010, Jen set out with two colleagues, Jon Leydens and Juan Lucena, to try to answer this question of *how*. Funded by a National Science Foundation grant to study "Engineering and Social Justice: Research and Education of (In)commensurable Fields of Practice," one of our goals was to determine the ways in which engineering education and practices erect barriers to enacting social justice values or concerns, and also what opportunities for integration exist.[3] Juan, who has significant interests in the history and culture of engineers and engineering, was committed to researching and writing about case studies of engineers who embodied or enacted social justice values, and one of our initial goals was to develop these case studies into teaching tools that engineering educators could use as exemplars in their classrooms.

[3]National Science Foundation grant #SES-0930213. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

As our research progressed, however, Jon, Juan, and Jen discovered that many barriers of consequence stood in the way of seeing social justice integrated into the engineering curriculum. We saw little problem with teaching a humanities/social science course on ESJ, and in fact a course called Engineering and Social Justice has been offered several times by our Division, Liberal Arts and International Studies, at our technical university, the Colorado School of Mines, and is part of the elective curriculum here. But we asked ourselves: if our students believe they learn about engineering in their "technical" classes, isn't that where we should be teaching about engineering and social justice? In other words, if we believe social justice is a topic students should be considering in their engineering work, shouldn't we be somehow intervening in how engineering science, design, and work are taught?

We had come to the conclusion that we did not want our research in ESJ to be merely descriptive (e.g., writing historical case studies), nor simply analytical (e.g., writing critiques of the engineering curriculum), though both approaches are important in shaping our thinking. Rather, we felt that we wanted the results of our work to be *transformative*. This meant figuring out a way to (1) communicate what we knew about ESJ to those who taught technical courses; (2) articulate to them why social justice is an important consideration, worldview, or set of values for engineers to know about, embody, or enact; and (3) work *as partners* with these educators to develop new activities, lessons plans, or assignments in which social justice became a visible and intentional concept in engineering problem identification and problem solving.

The project that emerged was an ESJ workshop for interested engineering educators at our university. Though a full description of the workshop is beyond the scope of this chapter, we provide the workshop objectives here for context:

At the end of this workshop, participants will have:

1. Developed a deeper understanding of the role that different forms of individual and institutionalized privilege play in shaping our views of social justice,
2. Begun to understand how the culture of engineering and engineering education, as reflected through engineering mindsets, can enhance or hinder opportunities to embrace social justice; and
3. Begun creating curricular interventions that can be taken back to engineering classrooms.

Point 3 is the most salient for the purposes of this chapter; one goal of the "transformative" ESJ workshop was for the three facilitators (Jon, Juan, and Jen, all from the humanities and social sciences) to work as partners with the workshop participants (all from engineering or applied sciences departments or administration units) to co-develop ESJ materials that could be used in the technical curriculum. Our hope as facilitators was that the workshop would have outcomes that mattered beyond the 2 days we were all together, and that ESJ would begin to "live" in the technical curriculum because engineering faculty had begun to own it as a concept, as something they would begin to define, adapt, address, and use in their capacity as engineering educators.

8.3 Sun Valley, Social Justice: Intervening in the Technical Curriculum

Junko was one of the participants of the workshop. Another participant happened to be a former resident of Sun Valley, the small community described in the introduction above, and an engineering alumnus and administrator at our university. He frequently shared in the workshop his experiences as a member of the "invisible" Sun Valley community, a community which bore a number of environmental and social ills that are frequently considered among the externalities of industrialization: waste dumping, isolating and consolidated poverty, poor flood management, and a lack of access to necessary goods and services, such as employment offices, banks, and supermarkets. Several weeks after the workshop ended, this participant took most of those who had participated in the ESJ workshop on a tour of Sun Valley, introduced us to residents and organizers there, and invited us to think about how engineering and social justice intersect in what might be considered our own backyard, as Sun Valley is only 13 miles from our campus yet unknown to most CSM students and faculty.

This was a particularly meaningful invitation for Jen and Junko. Junko had just agreed to teach the SED course, and saw an opportunity to link Sun Valley and the lightrail development with her interest in integrating ESJ in her course. She had also recently learned at a Center for Sustainable Engineering[4] workshop that social considerations are fundamental to sustainable engineering, distinguishing it from "green" engineering, defined by Anastas and Zimmerman (2003) in their seminal article as achieving sustainability through science and technology, though the definition subsequently has expanded to include engagement of communities and stakeholders (Abraham and Nguyen 2003) if not specifically social justice. With Jon and Juan, Jen had been thinking for some time about how ESJ concerns in the engineering curriculum almost always manifested as some sort of development project, and those development projects were frequently located in areas of the global south where engineering professors and their students were interested in "helping" the poor in other countries. Yet a significant body of research exists that suggests that such projects are incredibly difficult to plan, execute, and evaluate well, and—worse—they may even end up doing more harm than good. Furthermore, they require a tremendous amount of resources, may reify stereotypes students from the north have about poverty, development, and privilege, and are time-consuming to plan, conduct, and assess meaningfully (Epprecht 2004). The literature, including a book written by Juan, Jen, and Jon, details the challenges posed by engineering development projects abroad, including the possible re-creation of injustices in local communities (Lucena et al. 2010; see also Nieusma and Riley 2010).

[4]The Center for Sustainable Engineering is an NSF- and EPA-supported partnership led by Syracuse University and including Arizona State University, Carnegie Mellon University, Georgia Institute of Technology and University of Texas at Austin.

Yet studying Sun Valley offered a different opportunity to think about ESJ. Here was a local community with a long history and its own unique culture, not very far from our campus at CSM. It is a community that has a number of needs (some of which might be addressed through engineering practice, many of which would not) and which is typically referred to in local news stories as "impoverished," a place where most kids receive free or reduced school meals and which is remarkable primarily for its low voter turnout. And it was about to be transformed—perhaps dramatically so—by a major engineering project: the light rail system connecting downtown Denver with nearby suburbs.

Approximately 1,500 residents live in Sun Valley, considered the "poorest neighborhood in Colorado" with average annual *household* incomes ranging from $4,400 to $8,000, many times below the poverty level defined by the federal government (Griego 2010). The majority of the residents in Sun Valley live in public housing. According to journalist Tina Griego, "More than half of Sun Valley residents are 18 and younger, and most are toddlers and elementary school kids. No other neighborhood in the city comes close to this ratio of child to adult" (2010). Eighty-five percent of the homes in Sun Valley are headed by single mothers, and many of those mothers are teen mothers.

Furthermore, as noted above, Sun Valley is physically and geographically isolated from downtown Denver and surrounding neighborhoods. It is bounded on the west side by a large, busy thoroughfare called Federal Boulevard; on the south side by industrial warehouses; on the north side by the Denver Broncos football stadium; and on the east side by the South Platte river, which is both difficult to access for residents of the neighborhood and, paradoxically, prone to dangerous flooding, which killed a Sun Valley toddler in 2007 (Griego 2010). The neighborhood also abuts aging rail yards and their waste along with a retired electrical substation. Relatively well-to-do neighborhoods aren't more than a few miles away.

Within its boundaries, Sun Valley primarily features housing projects—two-story dwellings built very close to one another in block-like fashion, separated by yards and other green spaces; a large, apartment-style complex for young mothers called Decatur House; and a number of single-family homes in varying states of disrepair. There is an elementary school and a convenience store but no supermarket. Sun Valley also contains a sprawling office complex and parking garages owned by the Denver Housing Authority (DHA), though residents cannot access the DHA directly—thanks to a perverse design that literally denies direct access to some of the very residents it serves, the only entrance is on the far side of Sun Valley, facing Federal Boulevard. According to Griego, "More than nine of every 10 people in the neighborhood live in subsidized housing, and that not only makes Sun Valley unlike any other neighborhood in Denver, it makes Sun Valley homes unlike any other housing project in the city. It exists unto itself, not part of any larger residential neighborhood" (2010). Poverty, isolation, and the physical composition of Sun Valley make gaining access to amenities and opportunities—such as fresh food, banking, and employment—difficult.

However, these facts offer only a partial view of Sun Valley as a community. Sun Valley is racially and ethnically diverse, featuring a number of immigrant populations and a complex demographic make-up. Its population could be considered transient, with many of its residents staying only a short while in the neighborhood until they can transition into other neighborhoods or forms of housing. Also within its boundaries is the Sun Valley Youth Center, a recreational center that provides after-school activities for the neighborhood’s young people (http://sunvalleyyouthcenter.com/), meeting spaces for community government organizations and other political gatherings, and professional training and a computer lab for adults seeking employment development. Tha Myx, a community church, is also a powerful force in Sun Valley, organizing residents both culturally and politically and providing needed services (http://www.thamyx.org/get-involved/). Furthermore, a broad array of non-governmental organizations (NGOs), governmental organizations, and volunteers are active in Sun Valley community organizing efforts. For such a small community, it has a very active community government and a relatively large number of organizations who are community organizing and advocating for Sun Valley residents, though it should be noted that many of these organizations are subject to the vagaries of funding cycles and grant support.

While many residents stay in Sun Valley only for a brief time, others have lived in Sun Valley for decades. It is possible that this fact of life in Sun Valley—its physical constancy—is poised to dramatically change, largely thanks to the development of the “west corridor line” of the FasTracks lightrail system in Denver.

8.4 Sun Valley and the RTD Lightrail

In 1994, the Regional Transportation District, or RTD, began developing “fixed-guideway transit” (primarily lightrail, in this case) in the Denver metropolitan area, and has since constructed Central, Southwest, and Southeast Corridor lines. Further lightrail construction was approved in 2004 by voters who agreed to an increased sales tax: this approval was called FasTracks and includes new rail and bus lines and expansions of the existing Corridors. The development of the West Corridor line is a significant element of the FasTracks project (CTOD 2011, p. 15).

However, FasTracks, though an RTD project in the technical sense, is not “owned” by RTD. A number of other organizations, agencies, businesses, and coalitions are involved in the project’s planning and implementation. These organizations and stakeholders include, but are not limited to, cities (such as the City and County of Denver and the City of Lakewood); housing agencies (such as the Denver Housing Authority and Metro West Housing Solutions); nongovernmental agencies and organizations (such as the Urban Land Conservancy) and government agencies (such as RTD and the U.S. General Services Administration). For example, the nonprofit Center for Transit-Oriented Development (CTOD) has been a major player in FasTracks at the planning stages.

The portion of the FasTracks project that has the most relevance for the residents of Sun Valley is the planned Decatur/Federal Station, located in Sun Valley and targeted for completion in 2013. According to an RTD fact sheet, by the year

2030, more than 4,000 riders per day could exit and enter the lightrail system at the Decatur/Federal Station; this number could substantially increase on days when there are National Football League (NFL) games at the football stadium or other local events: stadium turnstile gates are located right off of the stadium (RTD, n.d.). Furthermore, 2,000 parking spaces are planned for this station, bus access will increase, and there will also be pedestrian and bicycle access and accommodations.

It could be argued that development stemming from the new Station has the potential to improve the quality of life for Sun Valley residents. The station's arrival could, for example, create more job opportunities. The industry- and warehouse-intensive areas that surround Sun Valley now are not conducive to diverse forms of employment, and increased development would undoubtedly create jobs in the service sector, in particular, which could be useful for Sun Valley residents who need to find work that is close to their homes, rather than transportation-intensive jobs elsewhere. Development could also provide amenities, such as grocery stores, banks, and so on, to residents. It is currently inconvenient or quite difficult to access such amenities in Sun Valley. Finally, the CTOD plan calls for the "redevelopment of public housing (Sun Valley) into mixed-income, mixed-use development" (p. 24). Ideally, this would include newer, more modern housing that does not carry the stigma of being "the projects" and which improves the quality of life for low-income residents.

But even with the best intentions in place, growth like this can sometimes happen with little concern for issues of social justice. It may ignore cultural and social outcomes for current residents that are difficult to predict or measure, such as the threats of displacement, disenfranchisement, and alienation. As Valderrama argues in this volume, the "technical" assumptions behind the planning of transportation models are not neutral and have built-in biases towards certain population groups that have the potential to create or exacerbate injustices. These outcomes are often a result of rapid gentrification, which ignores social inequities, relocates them to other areas, or otherwise exacerbates them, even if inadvertently. At the very least, the construction and completion of the station will lead to significantly increased foot traffic in and around Sun Valley, which could have several unintended consequences, some positive and some harmful. Or as Valderrama shows, the design of access roads and parking nearby the station could be made primarily for people who own cars, which is not always the case for Sun Valley residents.

According to Griego, the history of Sun Valley has given its residents a number of reasons to be wary of grand social and economic plans: "That many residents doubt they will have a genuine say in shaping the neighborhood's future is not surprising. History, after all, has taught them so. But, they also have a hard time envisioning that future and they're sure as heck not convinced it will be brighter" (Griego 2010). As a result of these historical practices of exclusion and segregation, some community members have seen the lightrail project as evidence that gentrification is part of a larger development plan intended to drive the housing projects out of the area, and they fear that no- and low-income families will be excluded from the benefits of development, as frequently happens with technological and economic developments such as this one (Decatur discussion group summary 2007; Ottinger 2011).

8.5 Sustainable Engineering Design

Through our colleague at the ESJ workshop who had lived in Sun Valley as a young person, we began to make connections with people who had worked in Sun Valley for a long time and who understood both its challenges and strengths. We wanted to get our students thinking critically about social justice in their own city, and about their relationships to technological progress, community development, and engineering design. Motivated by a desire to work together following the workshop and with a shared commitment to sustainability and social justice, Jen and Junko decided to develop an introductory module related to Sun Valley that could be piloted in Junko’s Sustainable Engineering Design (SED) course in the fall of 2011.[5]

The SED course is designed to provide a comprehensive introduction into sustainability concepts from an engineering point of view, and acts as a complement to the undergraduate capstone design course, which includes only a single lecture about sustainability during its two-semester course sequence. This course includes work with Life Cycle Assessment (LCA) software. Social considerations, a key aspect of sustainable engineering design, are integrated throughout the course. The textbook (Graedel and Allenby 2010) explicitly considers individuals and society from beginning (Chapter 1: Humanity and Technology) to end (Chapter 27: Looking to the Future), and closes with the following:

> …We must approach the technology-society-environment web…in a *holistic* fashion, a *connected* perspective, a *parsimonious* use of resources, and a *metabolically benign* approach to design and use…. The twentieth century has turned out to be one of major anthropogenic change on the planet on which we live. The twenty-first century must be one in which we do better—measuring our every action against its impacts on the environment, on society, and on sustainability….

The textbook was augmented with additional reading that, for example, examines the roles of economics, governance, and community in sustainable development (Ramaswami et al. 2007).

Learning outcomes for the SED course include that students will demonstrate the ability to:

- Display sufficient familiarity with the terminology associated with sustainability and sustainable engineering to write effectively about the topic,
- Compare and contrast traditional engineering design and analysis approaches with those associated with sustainable design, in particular those that go beyond the triple-bottom-line approach to include considerations of social justice and socio-technical integration,

[5] The Sustainable Engineering Design (SED) course was originally developed by Dr. David Muñoz, a mechanical engineering professor who was also the director of the Humanitarian Engineering program and passionate about teaching students to think more broadly about engineering. Dr. Muñoz piloted the course twice before offering SED as an official course in Fall 2009. After Dr. Muñoz’s retirement, Junko volunteered to teach the course in Fall 2011 and, with Jen, modified the course to explicitly include social justice considerations, e.g., by adding language to the course learning outcomes as detailed above.

- Apply a working knowledge of SimaPro, a commercially available LCA tool, and
- Work in teams to effectively write a project report and give a presentation that describes the connection between the concepts of sustainable engineering and their work, the approach they took and their conclusions and recommendations for future work.

Twenty students enrolled in the course: 13 were senior undergraduate engineering students (nine environmental, three civil and one mechanical), seven were graduate students (four environmental, two mechanical and one civil). Eight of the students were female, evenly split between graduate and undergraduate students.

8.6 The Sun Valley Module: Engineering Practices, Social Justice Practices

One particularly sticky point for engineering faculty intrigued by *social justice* and wanting to figure out ways to study it or incorporate it in classes is that it seems to defy definition. The range of groups, individuals, and movements who are or who claim to be fighting for social justice is vast, and as a concept, one of its strengths is that it is somewhat fluid. A group fighting against a municipal waste facility being sited in a low-income neighborhood already over-burdened with toxic or industrial processing and waste is fighting for social justice, just as a collection of parents arguing for a more equitable taxation system to rectify problematic distribution of textbooks or computers at their children's under-resourced elementary school are. As Donna M. Riley argues, narrowing social justice to *one* definition of social justice restricts its usefulness (Riley 2008, p. 5).

Yet to retreat to a "we know it when we see it" definition of social justice may prove alienating or inaccessible in an educational setting, particularly with engineering educators, who may feel the need to "operationalize" challenging concepts. We resist the scientistic desire to both concretize the definition for and "measure" social justice, but we think it makes sense to provide our own working definition here, if only so that our assumptions are made clear and our commitments transparent. For the purposes of this chapter, we think of struggles for social justice as being struggles that attempt to redress the unequal distribution of goods, rights, or opportunities, or to challenge policies or practices that exacerbate inequalities among groups of people. The emphasis in our definition is not necessarily on individual cases of rights, difference, or inequality (one person being poor and one being rich, say) but on the *systems* and/or practices that create, exacerbate, or conceal inequalities for particular groups or classes of people. For that reason, we find that it may be counter-productive to focus only on rights or laws, for example, because cultural or legal definitions of rights may themselves be unjust and require challenge.[6]

[6] We are indebted to Brian Barry's excellent book *Why Social Justice Matters* (2005) for shaping our thinking on this topic.

In addition to this definition and based on our review of the literature and our own experiences, we are further guided by a few important principles related to ESJ and engineering education:

1. Engineering students working on SED projects who wish to emphasize social justice are most effective when they partner with other professionals or students from relevant disciplines, such as social scientists, social workers, or community organizers. This offers engineering educators and students an opportunity to experiment with supportive, meaningful ways to teach students about humility, privilege, and multiple forms of expertise. Unfortunately, this is not possible at our own institution given the school's sole focus on engineering and applied science; this is one area in which creative partnerships beyond the walls of the university may be particularly valuable.
2. Engineering educators must work to trouble a "linear model" of engineering and social justice, wherein the equation "good engineering + willing community = social justice" is complicated. In other words, it is important to acknowledge that good intentions when paired with good technical skills do not automatically produce equitable outcomes for society. Courses at our own institutions such as Engineering and Social Justice and Engineering and Sustainable Community Development are good examples of where this kind of questioning is occurring in engineering education.
3. One of the great challenges of SED work that wishes to incorporate social justice is that students and faculty must focus on small, achievable projects, while at the same time keeping in mind large-scale system inequities that created the need for the project to begin with. Similarly, students must focus on individual projects and individual needs, getting to know community members on a personal level, *while at the same time* keeping in mind the complex social systems and organizations that affect individuals. Furthermore, individuals might experience social injustices as members of disenfranchised social groups; all of these factors may make SED projects difficult.

Keeping our working (flexible) definition of social justice in mind, along with these three guiding principles, we designed the following three-step module for students in Junko's SED class. Each step of the module was scheduled to take place during a 50-min class period.

8.6.1 First Step

Students were assigned to read Tina Griego's three-part series on Sun Valley (at http://www.denverpost.com/sun_valley) as well as a chapter on "Engineering with Community" from the book *Engineering and Sustainable Community Development* by Lucena, Schneider, and Leydens (Lucena et al. 2010). They were then given the following assignment:

> Imagine that your professor and a professional from the Denver Housing Authority have been awarded a small community improvement grant for the area of Sun Valley. Your professor and the DHA professional ask you to brainstorm ideas for how small-scale

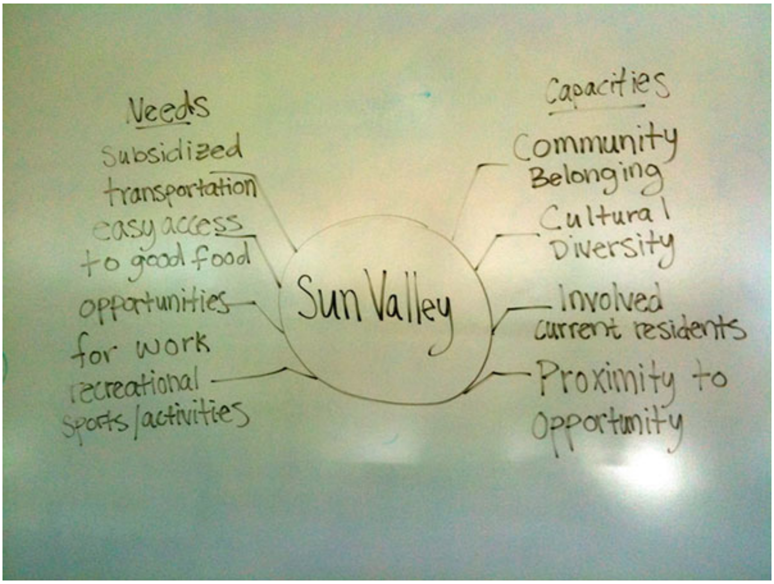

Fig. 8.1 Example of one needs and capacities map for Sun Valley from SED

engineering projects might improve the lives of Sun Valley residents, based on what you've read in Tina Griego's 3-part series. Write about how you might begin brainstorming and planning for such a project, using Lucena, Schneider, and Leydens as a guide.

During the class session, students discussed their responses to the assignment above, and then shared their responses with the class. Then Jen and Junko asked the students to form groups and create a "needs and capacities map" of Sun Valley, wherein they graphically sketched out the community's strengths and challenges (see Fig. 8.1). The emphasis in the discussion was on guiding students to see *what they did not yet know* about the community but would need to know, and on deepening their understanding of the structural bases of particular "problems" of social justice in the community.

As might be expected, the majority of student homework from this first stage emphasized the abilities that engineers or engineering solutions have to reverse the "disrepair and dilapidation" of Sun Valley itself and to decrease the "feelings of isolation" the community members there feel. This group of students—representing more than half of the class—immediately began "brainstorming solutions." Some proposed projects included redesigning roadways or footpaths to improve accessibility and transportation; developing community gardens; or designing systems to collect and distribute graywater. One student brainstormed a long list of projects and explained that after doing some initial research, he would "take this much shorter list and determine general cost and implementation strategies for the neighborhood. […]. Depending on budget and available manpower/machinery needed, I would take a revised list back to the community leaders and get their input, maybe even have a vote.” In this scenario, the engineering student would be in charge of determining the needs/problems faced by Sun Valley residents, an approach supported by the way the homework question is phrased (i.e., “your professor and the DHA professional ask you to brainstorm”) but then seriously critiqued in the reading. One student felt that engineering the neighborhood more effectively would create a “feeling of class” in Sun Valley, not meaning socioeconomic “class” but rather an elevation of “classiness,” a raising up: “While these [proposed engineering] changes could be surface only, if engineered correctly, a feeling of class could be injected into the community. This class could in turn lead to a change in the perceived general societal ranking, improving the way the community sees itself.”

But there was also some acknowledgment that typical engineering problem-solving (EPS; see Lucena et al. 2010) approaches might not work well in Sun Valley. Two students didn’t identify engineering solutions at all, but felt that social solutions—such as improved education—were the only way to “improve” life in Sun Valley. Approximately one third of the student responses noted that they did not have enough information to design a project, and would need to get to know community members better first. In fact, one student noted,

> The community appears to consist of people from many different cultures and histories. Singularizing the community to be a low income one that makes X thousand dollars on average annually, would be dismissing the various concerns that cultural differences may bring about. No problem can be summed up as an income issue. The one thing that would not be defined [by engineers] however is the problems. Defining the key groups of people should be followed with interacting with them and having *them* define their problems.

This quotation is remarkable because it acknowledges the importance of asking who defines the problems to be solved: in engineering education, typically, *engineers* define problems, or solve problems given to them by industry, corporations or the military. In a case such as Sun Valley, problem-definition may be much more complex. Similarly, another student wrote:

> Based off of the readings, it is easy to come up with problems that actually are not the primary problems of the residents. Having also travelled to various countries I have seen this. The other problem is [that] social constructs are often ignored by the EPS method of solving problems. Engineering needs to be incorporated with communities and not separate from them.

Two students said that they would begin the project with “self-reflection” before beginning to do research in Sun Valley itself and trying to understand effective ways to engage the community.

8.6.2 Second Step

Students were asked to complete a second set of readings, this time focusing on materials produced by those developing the lightrail line through the west corridor of Sun Valley, including a station in Sun Valley, and RTD’s community meeting summary with the residents of Sun Valley, wherein residents expressed their concerns about the lightrail development. During this class period, students discussed the regional and local planning documents, and asked key questions related to ESJ, namely, who benefits and who loses from such projects (see Baillie 2006)? In what ways might different social values, such as environmental sustainability, economic development, and social justice, collide?

For example, students pointed out that, from an environmental policy standpoint, the lightrail system would most likely ease traffic burdens and therefore the types of pollution that contribute to poor air quality and climate change. It could also provide needed transportation access for community members seeking employment outside of Sun Valley. At the same time, many Sun Valley residents worried that the lightrail station and development plans so near the Broncos' football stadium would lead to rapid gentrification, which might displace their residences and lead to a disruption of their community life. They were concerned that residents' voices were not adequately being considered in planning processes, and that the development efforts were an example of wealthy developers aiming to become even wealthier. Although we did not come to any satisfactory answers to these questions, the discussion indicated that students were beginning to think more critically about who might benefit and who might lose in the case of Sun Valley's lightrail development. In short, they were beginning to think about social justice.

The former resident of Sun Valley who initially had introduced our faculty ESJ workshop to that neighborhood also visited our class during this second session. He talked about his experiences as an immigrant living in Sun Valley for many years, and sensitized students to a number of factors they had not considered when devising solutions to the problems they identified in Step One. Meeting this former resident also personalized the problem-solving process for the students; he encouraged them to think of Sun Valley not as a community of "others," but as a community made up of individuals subject to a number of social challenges and opportunities, both in and out of their control.

The second set of student homework emerging from this step of the module acknowledged the ways in which the lightrail station could be a "win" for some community members in Sun Valley and a "loss" for others. An example from a student response in Fig. 8.2 illustrates. One student acknowledged that, given Sun Valley residents' treatment in the past and their lack of access to systems of

Possible Impacts:

Positive	Negative
• Increase of people in area	• People who live in Sun Valley do not have the funds to ride lightrail
• Economic benefits, more people using lightrail	• Increased people in their community who do not belong there
• Area will begin to develop-more job opportunities	• Potential to lose homes and have to move
	• If area begins to grow, real estate prices will increase

Fig. 8.2 Excerpt from SED sample homework for step 2

privilege and power, the hoped-for benefits from the lightrail station might not accrue to the community:

> In my opinion one of the largest risks is that the goods of the addition of the light rail [are] unable to trickle down to the Sun Valley residents. Whether this is due to access limited by money or otherwise, if the addition of the rail is unable to help them it will just further leave their needs unmet.

Most student responses argued that Sun Valley residents needed to be meaningfully included in decision-making processes about the lightrail station, though a number of students also acknowledged that the residents would be at a disadvantage when compared with other, potentially more powerful, players. For example, one student wrote that the critical issue in the Sun Valley project was involving multiple stakeholders in decision-making processes:

> For the Sun Valley community, the stakeholder that has been least involved in the planning of development has been the residents. Whether intentional or not, this group potentially has the most to gain or lose from this development, and should be considered as such.

This student also acknowledges that not all stakeholders are treated as equals, and that some may have a more powerful say than others in determining their future.

However, this student finishes his homework by suggesting that what is needed is more and better education; he does not address the issue of the lightrail project head-on. His response is typical of many of the responses; these circumvent the role of engineers and engineering in their critiques of or concerns about the lightrail process. While responses such as this student's acknowledge an important structural problem—the inequities inherent in our education system—they do not address the role that engineering or technology may play in perpetuating such inequalities.

Such a gap in student understanding is most likely directly related to Erin A. Cech's conceptualization of "depoliticization" as being a central feature of engineering culture. Cech argues,

> Because science and mathematics knowledge is understood to be the basis of engineering expertise, engineering work is assumed to be carried out objectively and without bias. Indeed, this is the foundation of logical positivism, the belief that science and engineering work can be separated from messy "social" concerns as long as proper scientific and engineering methods of inquiry and design are followed (Chap. 4, p., in this volume xxx).

The student responses that do not connect social justice and engineering directly, but rather see them as discrete subjects, suggests an internalization of depoliticization. Students are not always sure how to evaluate or critique technological inequities, may see them as outside their domain of interest or expertise, and may instead shift their concerns to other systems in which engineering is not so complicit. It also suggests that the module needs to do a better job of highlighting the role that engineers and engineering play in decision-making when it comes to designing sociotechnical systems, of creating "cultural space" for overt discussions of depoliticization and its effects.[7]

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[7] As far as we are aware, the institutionalization of such discussions regarding the politicization of engineering are relatively absent from engineering education, save in program's such as Rensselaer Polytechnic Institute's design studio program (see Chap. 2 by Nieusma, this volume).

8.6.3 Third Step

Finally, we challenged students to consider how social considerations might be quantified in sustainability analyses. Students were asked to read about different measures of social sustainability (Hutchins and Sutherland 2008), including the United Nations Division for Sustainable Development framework (summarized in the table below). Hutchins and Sutherland, after reviewing a number of efforts to assess business sustainability, ultimately define and demonstrate the use of indicators of labor equity, healthcare, safety and philanthropy in evaluating the social sustainability of supply chains.

Theme	Sub-theme	Indicator
Equity	Poverty	Percent of population living below poverty line
		Gini index of income inequality
		Unemployment rate
	Gender equality	Ratio of average female wage to male wage
Health	Nutritional status	Nutritional status of children
	Mortality	Mortality rate under 5 years old
		Life expectancy at birth
	Sanitation	Percent of population with adequate sewage disposal facilities
	Drinking water	Population with access to safe drinking water
	Healthcare delivery	Percent of population with access to primary healthcare facilities
		Immunization against infectious childhood diseases
		Contraceptive prevalence rate
Education	Education level	Children reaching grade 5 of primary education
		Adult secondary education achievement level
	Literacy	Adult literacy rate
Housing	Living conditions	Floor area per person
Security	Crime	Number of recorded crimes per 100,000 population
Population	Population change	Population growth rate
		Population of urban formal and informal settlements

After reading Hutchins and Sutherland, students were asked to discuss the following:

> This manuscript describes a variety of social indicators that may be used to quantify the sustainability of supply chains. Which indicators do you believe are most important? How can these be quantified? What issues might you anticipate in applying these indicators? How could these indicators be applied to the light rail station in Sun Valley?

During the class session, students shared their responses to the assignment above. The discussion centered on prioritizing indicators and issues related to quantifying these indicators in Sun Valley. In particular, the lightrail development was difficult to link directly to changes in indicators, primarily because the types of indicators identified by LCA software and in the reading had to do with analyzing company or supply chain performance rather than a public-works project like the lightrail.

The majority of responses for this third step were often illustrative of the sort of technical/social binary we noticed above and which Cech (Chap. 4, this volume) has theorized, where students were challenged by having to think about ways in which engineering practices (such as LCA) might ignore, if not contribute to, the creation of social inequities in a place like Sun Valley. Several responses took for granted the social indicators proposed by Hutchins and Sutherland, simply listing those that they thought would be the most important for a quantitative social sustainability or LCA approach to examining the lightrail project. Some of these responses suggested that measuring the safety records or philanthropy rates of particular companies or organizations would be the best approach; others suggested that health and education metrics would work best in Sun Valley. A number gave carefully thought-out and reasoned support for why access to clean food and good education were useful indicators, and several noted that these indicators were difficult to adapt to an urban environment in an industrialized country, noting that they would have to be used with careful judgment.

The homework prompt invited students to do this sort of analysis, and certainly grappling with appropriate measurement is something that engineers, scientists, and social scientists strive to do. However, focusing only on the particular indicators proposed by the assigned reading has its limitations. It may encourage engineers to zero in on needs rather than capacities, for example, or to make inaccurate or problematic assumptions about groups, social class, behaviors, and motivations. For example, one student arguing that health was a good indicator wrote,

> One of the main issues in applying health is getting the people to care about themselves, it seems as though there may be a lot of depression in lower income families and to get them to understand the quality of life would be a major step. The main issue that would arise in Sun Valley for education would be getting quality teachers who are able to motivate the children to learn and create a better life for themselves.

It is possible that some of these assumptions are true, or contain some truths, but it is equally possible that they are not accurate and that acting on them could promote unjust ways of seeing, thinking about, and treating others. We see here evidence of Cech’s second characteristic of engineering culture, meritocracy. According to Cech, meritocracy is a widespread belief among engineers, and can be defined as, “the belief that success in life is the result of individual talent, training, and motivation, and that those who lack such characteristics will naturally be less successful than others” (Chap. 4, this volume, p. 7). The problem with this belief—which is held not just by engineers but by many Americans—is that it “denies the structural foundations of inequality—foundations that may include the work of engineers” and furthermore “frees engineers from the responsibility to design accessible or inexpensive products that alleviate social problems but may have little profit potential” (Chap. 4, this volume, p. 9). A more sophisticated social justice lens, on the other hand, would invite this student to think critically about his own assumptions and to examine whether structural factors, rather than individual or personal flaws, might be at the root of the issues facing Sun Valley residents. We reflect further below on how space for this kind of discussion can be made in certain kinds of engineering classrooms more easily than others.

On the other hand, there was also significant awareness among several students that not only were social factors frequently difficult to quantify, but that the proposed model from the reading and the LCA software itself would not be up to the task of measuring social sustainability. Indeed, the field of social and socio-economic life cycle analysis (S-LCA) has emerged within the past decade and has not yet developed to the level of establishing databases with even generic background information regarding social impacts, readily evaluating qualitative data, or considering chains of causality for social, environmental and micro-economic impacts (UNEP 2009). Clearly, quantifying particular social or economic metrics is important, and the results of such study can be used to further social justice goals in many cases. However, our teaching of this module suggests that some S-LCA approaches are more holistic and appropriate for particular contexts than others. Several students intuited this. Rather than taking the method from the article at face value, nearly half of the students adopted some critical distance from the approach and questioned whether social indicators could or should be accurately or usefully quantified at all. According to one student,

> These indicators have a number of flaws, which leads to a conclusion that no social rating may suffice or result in useable data […]. In the same way that 'natural' and other green washing words and images have harmed the concept of environmental sustainability, tacking labels on companies based on surface-level indicators may ruin the point of social analysis.

Similarly, another student argued,

> Although quantifying the indicators mentioned in the text may give an overall feel of the social sustainability within a place, I think that they are quite sterile and oversimplify the social and cultural ethos within a society and nation. I do not believe that one can quantify social sustainability with ONE general number and apply it to a group of INDIVIDUALS. So perhaps these indicators are better used in a corporate rather than a cultural setting.

Two students, including this one, acknowledged that the LCA approach suggested by the article would be most appropriate for corporations interested in supply-chain-type analysis, not for examining community impacts more broadly. Several suggested that it is perhaps for this reason that corporations are unable to think meaningfully about social sustainability broadly defined. When we teach the module again, we will seek to implement an S-LCA approach that lives up to the students' expectations in this regard.

8.7 SED Assessment

A detailed description of our assessments for the module and for the course is beyond the scope of this chapter, but we briefly describe some of the student comments to our pre- and post-surveys here, simply to give a sense of the strengths and weaknesses of incorporating social justice into an engineering classroom the way we did with this module. Cech advises in her chapter for this volume that social justice cannot be addressed briefly or willy-nilly; no single lecture or assignment suffices to undo the deeply held ideologies of depoliticization and meritocracy. Rather, argues Cech, sustained and meaningful openings must be made in engineering courses in which these ideologies are discussed. We agree wholeheartedly with Cech, and hope we began some of that work with our brief module.

At the same time, we are sympathetic to the time pressures and other demands on engineering faculty, and also wonder how many engineering faculty would feel comfortable teaching about topics such as these. This is not a reason to withdraw from such efforts, but merely an acknowledgment of the barriers that exist to "making cultural space" for such discussions in engineering classrooms. In some ways, our task was easy: SED already lent itself, in terms of subject matter, to discussions of sustainability and social justice. On the one hand, this may suggest an area in which ESJ efforts can expand: it is possible that those who work in sustainability and engineering may be natural allies, for instance. We are not sure such efforts would be as easy in other courses where the "social" seems extraneous or unconnected, even though we understand that it is not.

Twelve students total completed both an initial and a final survey. This is a very small sample, but some tentative generalizations can be made by comparing the two sets:

At the beginning of the course, students on the whole had a vague sense that social justice has something to do with rights and fairness, and that these were terms that were agreed-upon by society. By the end of the course, we can find some evidence that suggests that students were embracing a more complex definition that also included problems posed by unequal access to opportunities and the cumulative or targeted impacts of injustice. For example, a student who we will call John defined social justice at the beginning of the course as "based on a large-scale agreed upon set of moral and other philosophical norms that can be applied preemptively/proactive[ly] to adjust anything that may not best fit the survival of said society." Similarly, "Peter" initially argued that social justice is simply "treating individuals according to their natural and civil rights." And "Margaret" early on defined social justice as "Equitable or fair baseline for all humans and their interaction with each other and their environment." Nine of the 12 responses on the initial survey contained references to rights or fairness and used somewhat sterile, abstract language to do so.

Some of these rights-based definitions persisted at the end of the semester as well, with three of the final responses looking very similar to the initial rights- and fairness-based definition. But several other responses suggested a shift in student thinking from simply defining justice within a legalistic, rights-based framework (often known as retributive justice) to thinking also about access to opportunity, resources (distributive justice), voice in decision-making (procedural justice), and technology. For example, John, who provided the fairly abstract definition of social justice above, shifted his end-of-semester definition to include environmental aspects of justice and an emphasis on those who might be disadvantaged by decision-making: "Fairness in both societal and environmental aspects, not unfairly disadvantaging group/locale." Similarly, "Bill" who had initially defined justice as just being on a "society wide level," by the end of the course pointed to social justice as being the need for "protection of [the] needy against [the] more powerful." Peter also noted that social justice must do something about "correcting injustices created by hierarchical class, race, and other structures," arguably a more nuanced and sophisticated definition than his simple rights-based one above. Margaret also referenced the importance of paying attention to equality among "stakeholders" in a given situation—a more contextualized definition of social justice than she began with. Finally, "Sam" initially defined social justice in a market-based sort of way, as "the ability for society to push the development of a particular issue. If society wants sustainable development they create a demand for it and that becomes a norm." By the end of the course, he too had moved to a definition of social justice that emphasized not just rights but also opportunities: Social justice is "the thought that all people deserve the right to access basic necessities. Also that people will do what is right for them given opportunities."

8.8 Conclusion

These are subtle rather than dramatic shifts. In order to further support our inferences from these surveys, we would need to complete student interviews and more rigorously analyze student homework from the Sun Valley module. We also wish we had provided students with our working definition of social justice during the module, and/or had them complete a reading or readings more geared to social justice and not simply focused on sustainable development; our colleague Juan Lucena does this kind of work in his course Engineering and Social Justice, and this could be a model to consider for future modules. In that course, Juan defines social justice practices as "attempting to provide an equal distribution of rights, opportunities, and resources in order to enhance the capabilities and reduce the risks and harms among the citizens of a society." Such a definition could provide students with a basic point of discussion.

Furthermore, the way we structured the module may have exacerbated the blurring of the lines between "development" and "social justice," which we are actually interested in teasing apart, conceptually. In particular, we are very interested in more fruitfully exploring the tension between attempting small-scale, feasible engineering projects in concert with communities on the one hand, and raising consciousness about the systems of inequality that produced the need for those small scale development projects to begin with. Students must learn to grapple with the distinctions between the two modes of thinking and operating, paradoxically dealing with the challenges of both at once.

If we use the module again, we will also rewrite the prompts such that students are encouraged to look more specifically at the engineering aspects of the case, and will guide them in a more careful discussion of the role engineering and technology can play in perpetuating (in)justice. Given unlimited time and resources, a more complete study of the Sun Valley case would also have led us to complete interviews with Sun Valley residents and community planners to gain more insight into the impacts the lightrail project is having and will have on life in that community. It may also be interesting, in the long run, to explore possible partnerships or deeper relationships between our university and the residents and organizations of Sun Valley. We believe strongly in the importance of encouraging students to look near their own universities and communities as they think about who and what needs to be "developed" or better yet, where social justices might be occurring. Perhaps most importantly, we will brainstorm ways in which both of Cech's ideologies—depoliticization and meritocracy—can be examined critically in some way, and incorporated into our discussions of social justice.

Nonetheless, we would argue that this cursory analysis of the homework and initial and final surveys points to an increase in complexity and sophistication with regard to thinking about social justice among some students, and suggests possible mechanisms that engineering educators might consider for incorporating social justice into their classrooms. These findings suggest that students began to move away from simply defining social justice as the distribution of "rights" or as a bland dispersal of "fairness," and moving toward more nuanced definitions that include critiques of social systems rooted in particular contexts; such a move may indicate cracks—however minute—in student beliefs in meritocracy.

Similarly, students' final definitions of social justice suggest an awareness that social structures—constructed by politicians, policymakers, engineers, and others—may lead to a lack of access to opportunities as well as rights, and therefore perpetuate *injustice*, a beginning awareness of flaws in the ideology of depoliticization. Although we never provided students with a definition of social justice, nor gave them specific readings on social justice, the inclusion of the Sun Valley case seems to have motivated students to think more critically about how justice and injustice are created by human decision making, and to think more carefully about how to involve citizens in such decisions. For many students over the course of the semester, social justice shifted from being about the rights of individuals to being about the inequities created by systemic imbalances, which is an awareness we hoped to foster through the inclusion of the module. While there is room for improvement and expansion in terms of how we delivered the module, we believe that these initial indicators of student learning are positive, and may provide one model for thinking about how to make social justice live in the technical curriculum.

Finally, we would encourage other engineering educators to consider ways in which they might team with their colleagues in the humanities and social sciences to design modules that will work in their own engineering classrooms. Our collaborations revealed to us the ways in which we might learn from each other as we endeavor to break down the walls between "engineering" and the "social"; the ways in which our students both hunger for and resist discussions of fairness and equity; and our own beliefs about what is possible in the engineering classroom. We believe that our students lost nothing by taking the time to consider the social in their engineering coursework—except perhaps for some potentially problematic beliefs about what engineering is and does—and may have gained a deeper appreciation for social justice concerns.

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Chapter 9
Integrating Social Justice into Engineering Education from the Margins: Guidelines for Addressing Sources of Faculty Resistance to Social Justice Education

Jon A. Leydens

Abstract A more socially just engineering profession will necessitate multiple changes to its pipeline—engineering education. If social justice education is to extend across and within the content of the engineering curriculum, it will need to inform and reform multiple educational components: foundational, design and engineering science—as well as humanities and social science—curricula. This chapter identifies common sources of faculty resistance to integrating social justice education in one of those curricular components: humanities and social science pedagogy and content. To facilitate the integration of social justice education in humanities and social science curricula within engineering education, this chapter proposes guidelines that address those sources of resistance. Although initially designed for humanities and social science curricula, the guidelines proposed here have multiple implications for addressing faculty resistance across the entire engineering curriculum. The chapter concludes with an overview of the strengths and weaknesses of the guidelines.

Keywords Social justice across the curriculum • Engineering education • Faculty resistance

9.1 Introduction

What are common sources of faculty resistance to social justice (SJ) education? What guidelines can help advocates of SJ education ethically and meaningfully engage university faculty in discussions on whether, why, and how to integrate SJ into their courses? This chapter addresses these two questions, focusing on humanities and social science (HSS) curricula within two specific contexts: the context of

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engineering education, and the context of broad social justice across the curriculum (SJAC) efforts.

To understand the context in which those two questions are situated, it is important to first have, as background, a brief overview of engineering and social justice and SJAC efforts (see Chap. 2 by Nieusma, this volume for more in-depth coverage). An overarching goal of those advocating for engineering and SJ is to position "social justice at the centre of engineering practice" (Baillie 2006, p. 69). Members of the Engineering, Social Justice and Peace (ESJP) Network are committed to practicing engineering to promote SJ and peace, and realize that commitment in two broad ways:

> First, by understanding how technology and society are co-constructed, we are committed to identifying and dismantling specific occurrences of injustice related to engineering and technology. Second, in collaboration with community groups facing specific structures of injustice, we are committed to devising and developing technologies and other engineering solutions (broadly conceived) to the problems they face (Engineering, Social Justice and Peace Network 2011).

At several institutions, efforts are ongoing to launch or implement SJAC, including Middlebury College, DePauw University, Scripps College, Furman University, Oregon State University and others (e.g. Skubikowski et al. 2009; Skubikowski 2009; Roper 2007). SJAC involves meaningfully integrating social justice education across a university curriculum, often via faculty development initiatives (Skubikowski 2009). Thus, successfully addressing faculty resistance plays a pivotal role in any effective SJAC initiative.

To be successful within the engineering curriculum, SJAC must truly span all its major aspects—courses in the foundational core, design, engineering sciences, and HSS. SJAC interventions have been described in scholarly literature for multiple disciplines, such as in math (Bremser et al. 2009), foreign languages (Graf 2009), engineering (Riley 2012), and literature (Palmer 2009). Within engineering education contexts, an SJAC initiative dependent exclusively upon the HSS curricula is doomed to fail. Such an initiative sends the message to students that SJ is important only to non-engineers, or only relevant in "non-technical" contexts, and is not an explicit component of learning to think and act like an engineer. By compartmentalizing SJ in that way, educators do SJ, engineering, and students a disservice. Hence, an assumption undergirding this chapter is that the HSS curricula that integrate SJ are necessary but not sufficient for effective SJAC initiatives, and need to be interdependent with SJAC efforts that run across the *entire* engineering curriculum.

Although faculty autonomy (as a value) and lack of collaboration on pedagogical matters (as a practice) are common in academia, counter-cultural forces have shaped two fine examples of effective *collective* faculty responses to calls for curricular change (Skubikowski 2009). The first, Writing Across the Curriculum, was launched in the early 1970s out of local and national attention to student writing abilities. Unlike most educational fads, this one grew and endured. By 1988, just under 50 % of all U.S. institutions surveyed had Writing Across the Curriculum programs (McLeod 1989). Institutional structures often supported faculty development for such programs, including writing programs, centers for learning and teaching and others. A second form of collective effort involved the integration of instructional technology into higher education classrooms (e.g., PowerPoint, Clickers, Podcasts, and Tablets). Catalyzed partly by the availability of new technology, this effort was supported by learning and teaching centers and other institutional structures seeking to promote judicious, pedagogically sound, research-informed use of such technology (Skubikowski 2009).

So through these two examples, we know collective faculty action to transform pedagogical approaches and content is possible. But we also know there are many educational movements with less successful track records. What distinguishes the more from the less enduring and successful educational efforts? Answers to that question are complex and outside the scope of this chapter, but certainly one challenge-cum-opportunity centers on *faculty resistance*. Hence, any successful SJAC initiative will need innovative, locally tailored approaches to addressing such resistance.

9.2 Guidelines for Addressing Faculty Resistance to Social Justice Education

The data for my perspectives on faculty resistance come from multiple sources, including reflections on lived experiences, participant observations, and a literature review. For over 20 years, I have been an engineering educator, and the last 15 years have been at the Colorado School of Mines, a U.S. institution with undergraduate majors primarily in engineering and applied science. Within that context, I served as the Chair of the Writing Across the Curriculum (WAC) Committee from 1998 to 2011, so I understand and have ample lived experiences with multiple facets of faculty resistance, particularly in cross-curricular initiatives. As WAC Committee Chair, I conducted summer workshops for almost 100 faculty on a campus with roughly 250 faculty members. Although some of those faculty had been sent to the workshop by their department heads, on the final workshop evaluation, 100 % of workshop participants indicated that they would recommend the workshop to their peers. As a WAC committee, we were able to pass through our Undergraduate Council guidelines whereby all undergraduates now take four writing-intensive courses in junior and senior-level engineering or applied science courses.

Data has also emerged from my role as co-principal investigator (with Juan C. Lucena and Jen Schneider) on a National Science Foundation Grant focused on understanding the (in)commensurability between engineering and social justice. In that capacity, I have designed and implemented SJ micro-insertions in my own HSS courses and have co-designed a course called Engineering and Social Justice. With my co-PIs, I have also designed and delivered a SJ faculty development workshop. Participant observations occurred during and after the workshop and included observations on what occurred as well as reflections on how to improve workshop quality. Those experiences have offered insights into common forms of resistance to integrating SJ. Another contributing data source comes from interactions with engineering educators in the ESJP Network, via annual conferences and other professional encounters. I have also participated in social justice or diversity workshops in numerous institutional settings. Finally, a review of SJ education literature informs the guidelines for addressing sources of faculty resistance, particularly a collection on social justice education (Skubikowski et al. 2009) and work by professionals in the ESJP network.

9.2.1 Guideline 1: Enact Humility

This is the first of all the guidelines because it is the most important. It also extends across contexts: in aligning with relevant stakeholders and constituencies on campus, in faculty development workshops, and in our own classrooms.

When I began on my mission to convince engineering and applied science faculty to integrate writing into technical courses, I considered it just that: a mission to convince. What I soon learned is that faculty often come to writing workshops because they care about their students and students' learning, and faculty arrive with very different backgrounds, values, beliefs, and practices regarding learning and teaching. Learning to honor and respect those differences took humility and the ability to listen. Although one could place "a mission to convince" and "listening with humility" at opposite ends of a continuum, in my experience, the former will not happen without the latter. I was convinced from research and experience that integrating writing could dramatically enhance student learning of technical concepts (e.g., Leydens and Santi 2006; Russell 2001; Bean 1996). But before I could impart any of that passion or knowledge, I needed to learn how faculty came to the workshop table—what (mis)conceptions they brought regarding teaching, writing as a learning catalyst, how people learn, and more. Faculty want—and deserve—to be heard and understood before encountering the details of any educational reform.

The need to listen with humility is even more acute in the case of SJAC. Social justice concepts connect to, and often challenge, our core beliefs, values, and actions about human potential, societal organization, and a sense of systemic fairness and equality. Few subjects touch so close to the root of our sense of our identities and our social locations. In workshops I have facilitated or participated in, I have witnessed the kind of reductive judgments or labeling that can entrench or exacerbate resistance. Yet I have also experienced the kind of safe, supportive-yet-challenging atmosphere wherein participants seek to establish—or better, co-create—trust; in such an atmosphere, they are more apt to communicate across the experiential chasms that can emerge from differences in social locations related to (among others) culture, race/ethnicity, social class, age, sexual preference, religion, gender, privilege, (dis)ability, and awareness of global inequities.

In those same contexts, I have also been gently informed that something I said could be interpreted as offensive by groups outside my social location, and found myself profoundly impressed by how my lack of awareness was treated with such compassion—yet clarity. Through such contexts, I have also gained awareness of unearned and unequally distributed privileges, ones we all hold in various degrees. For instance, in my classes I sometimes illustrate cross-cultural issues by talking about experiences abroad with my wife, who is European, and my children, who are bilingual and bicultural. Yet a host of (initially unconscious) privileges were embedded in such statements; for instance, my homosexual colleagues are not as free to give similar examples from their own committed relationships, and colleagues who work as contingent faculty with incomes lower than mine often cannot afford travel abroad. So enacting humility is about recognizing that SJ conversations elicit faculty resistance in part because they open lived experiences of injustice, festering wounds, and discomfort with issues some would like to ignore or forget. Creating curricular and cultural spaces in which SJ discussions can foster faculty insight and growth remains a supreme challenge and opportunity. One of the most respected and experienced SJ workshop facilitators in the U.S., Diane Goodman, encourages us to find that balance wherein participants feel safe yet challenged; at the same time, participants need to recognize that they do not have the right to comfort, as SJ conversations can (and often should) produce discomfort (Goodman 2001).

In one of his political writings, Gandhi brings to light an important paradox. He states that his non-cooperation and civil disobedience movement "strives to compel action and to set an example not by…violence but by…unobtrusive humility" (Gandhi 1996, p. 49). In SJ education, it is important to understand the paradox of compelling action while enacting unobtrusive humility. Although enacting humility was placed first in terms of importance, the remaining guidelines are listed in terms of the institutional unit of analysis, ranging from broad, institutional-level concerns to faculty development and curricular issues.

9.2.2 Guideline 2: Identify Accreditation Constraints and Opportunities

Do accreditation guidelines serve as a constraint or opportunity for SJAC? In the U.S. and to some extent internationally,[1] engineering disciplines heed the accreditation guidelines of the Accreditation Board for Engineering and Technology (ABET) (ABET 2012). The ABET criteria that most concern cross-disciplinary initiatives include General Criterion 3, student outcomes, 11 statements about what knowledge, skills, and attributes graduating undergraduates should have attained or should show evidence of attaining[2] (ABET 2012). Seven of these are not strictly technical

[1] At present, ABET accredits engineering programs in 24 countries; see http://main.abet.org/aps/Accreditedprogramsearch.aspx

[2] ABET identifies these student outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Source: http://www.abet.org/engineering-criteria-2012-2013/

skills (c, d, and f–j) (Leydens and Schneider 2009). Even the remaining four that are primarily technical (a, b, e, and k) can involve sociotechnical dimensions.[3]

Whether accreditation guidelines serve as constraint or opportunity appears to be a matter of perspective. For instance, ABET has been depicted as a constraint to engineering programs that sought additional exposure to HSS courses "even as tighter [ABET] accreditation requirements make such curricular innovations difficult" (Chap. 4 by Cech, this volume, p. 77). At the same time, ABET has been seen as facilitating curricular and pedagogical experimentation (Nieusma 2011). These differences may stem from the inherent ambiguity of the guidelines. Researchers have noted that, "[b]revity and openendedness are two of the most striking features of [ABET] EC 2000 criteria; the latter, therefore, not only permit but demand interpretation" (Ollis et al. 2004, p. xiv).

Regardless of interpretation, two actions remain important for SJAC initiatives: to seize relevant opportunities to show how SJAC can help an institution and/or department realize accreditation goals, and to convincingly rebut any claims that SJAC serves as an obstacle to accreditation. The first action can be achieved in multiple ways, such as by showing which Criterion 3 student outcomes are addressed by courses that integrate SJ education. Often, in comparison with courses that involve no SJ integration, such courses place greater emphasis on, at a minimum, outcomes c (especially on the realistic constraints), e (with a broader perspective on what constitutes engineering problems), and f–j, with special emphasis on h, as engineering and SJ education raises questions on the broad social and other impacts of engineering solutions (e.g., see Baillie et al. 2010). Since courses that integrate SJ concepts tend to meet more Criterion 3 outcomes, their value for meeting accreditation goals is augmented. The second action can be enacted via hard data: that courses integrating SJ meet more accreditation outcomes can be demonstrated quantitatively by mapping course learning objectives to Criterion 3 student outcomes. One could also qualify the degree to which particular courses meet Criterion 3 outcomes by using a tripartite scale: primary, secondary, and tertiary emphasis. For instance, compared to a conventional thermodynamics course, a course in thermodynamics integrating SJ is likely to have more primary and secondary emphases on several Criterion 3 outcomes. The same may be true in HSS courses. Overall, however, it seems likely that factors other than ABET, and noted below, will most shape SJAC initiatives.

9.2.3 Guideline 3: Know Your Institutional Context

In what ways does institutional context matter? The capacity for any higher education institution to create vibrant curricular and cultural spaces for SJAC co-depends

[3] The need to transcend the technical-nontechnical binary is discussed in section 6a below.

on an institution's mission, goals, leadership, and culture. Those same components of institutional context also shape faculty perceptions on the nature of institutional support or resistance to social justice education.

Glen David Kuecker is an associate professor in Latin American history at DePauw University, and understands that social justice work requires a supportive institutional context. Kuecker's work integrates research and, when warranted, action to prevent injustice. After being involved in compiling data for a network that supported an anti-mining indigenous human rights campaign in Ecuador, the mining company in question decided to spend some of its social capital. It contacted two apparent acquaintances on the board of trustees at DePauw. The company then wrote a letter to DePauw's dean of faculty, expressing concern about the "very disturbing and unprofessional conduct of Dr. Glen Kuecker" (Kuecker 2009, p. 43). After looking into the charges, DePauw did not fire then-tenured Kuecker. Yet he notes that this outcome could have differed, "especially if a university's financial and symbolic capital is risked" by work that accompanies research-based action to prevent social injustice (Kuecker 2009, p. 53).

How resistant will faculty be to engage in SJ education, let alone SJ action, if an institutional context does not support such activities? This question has led social justice scholars to examine elements of institutional context. Some suggest that for SJ educational initiatives to succeed, proponents should possess particular kinds of background knowledge (St Clair and Groccia 2009): for instance, such knowledge could include diverse models of higher education governance, organization, and leadership (e.g., Birnbaum 1988), and knowledge on theories and models of change in higher education (e.g., Scott 1999; Kezar et al. 2001; Fullan 2007). For SJAC initiatives to succeed, SJAC proponents should understand how their institutions lead, govern, and arrange tasks into various hierarchies, departments, and divisions as well as how change processes differ according to academic context. Beyond general knowledge of higher education organization and change models, St. Clair and Groccia also recommend awareness of four specific elements of institutional context for SJ education:

1. Value Sets: Change toward any new set of values requires navigating existing institutional and departmental values; however, each discipline has its own value set and administrators' value sets often differ from faculty's. For instance, faculty may place more value on faculty autonomy than administrators. Thus, institution-wide change tends to be a complex and gradual process.
2. Power Structures. Since power is distributed across multiple levels, knowing who controls what is important; for instance, faculty tend to have power over the curriculum while administrators may have more power over interpretations of policies and resources to enact new curricular innovations.
3. Change Catalysts: A vision for and commitment to a curricular change like SJAC are both necessary for initial inertia but do not ensure SJAC will come to fruition; rather, proponents need to understand the process by which such changes are facilitated or impeded, especially the role of impatience, failure to listen, and more.

4. Mission and Vision: Since a mission statement ideally speaks to what an institution does to reach toward its vision, aligning SJAC with institutional mission (who we are) and vision (who we aspire to become) is crucial (St Clair and Groccia 2009, p. 74).

These authors underscore tailoring SJAC to the unique aspects of each institution, and partnering with key stakeholders such as learning and teaching centers (St Clair and Groccia 2009). Those ideas are echoed by others who advocate weaving SJ education into the established fabric of "ongoing practices and shared themes of the institution," and ensuring that such efforts are "informed by sincere and widely shared commitments to teaching intellectual and ethical values" (Altman et al. 2009, p. 101). To that end, Altman and colleagues integrated their SJ education efforts at DePauw University into a respected, established institute for ethics (the local driver of ethics across the curriculum), and a culture in which faculty development workshops have long fostered faculty growth. Other cultural spaces also fostered their SJ education initiative, including a social justice institute, which provided forums for idea and assignment sharing and a reading/discussion group for faculty. Also, they piggybacked on an existing role model ethos, premised on the belief among faculty that students become more ethically reflective when faculty model such behaviors. They also bring in nationally recognized speakers (e.g., Cornell West) for high-profile annual events. Collectively, these events helped open more curricular and cultural spaces so SJ runs across disciplines (Altman et al. 2009).

To effectively address faculty resistance to SJ education, it will be crucial to align SJAC efforts with another key institutional stakeholder: campus diversity initiatives. This is particularly relevant in light of research on engineering students with solid GPAs who leave engineering because (among other reasons) they do not feel a sense of belonging in engineering contexts (Rodgers and Marra 2012). However, it is important to transcend superficial diversity (Prashad 2009). Prashad notes that superficial diversity initiatives may focus their efforts on creating the semblance of diversity, perhaps by bringing diverse students to visit campus for brochure photographs. On my campus, some organizations sell Navajo fry bread, egg rolls, breakfast burritos and more to benefit varied diversity initiatives. Although raising funds is necessary, such initiatives also need to *raise awareness* of institutional and broader, systemic inequities.

When diversity initiatives advocate for multiculturalism, they only scratch the surface of raising awareness of social inequities. Although multiculturalism provides deserved recognition to those who had been previously marginal or invisible, multiculturalism today has been described as "an impediment for the construction of an anti-racist policy" (Prashad 2009, p. 121). Multiculturalism blocks such progress because it is a bureaucratic approach adopted by institutions that do not address "White supremacy from above;" institutions still connect human progress almost exclusively with European civilization and fail to unveil the biases of gatekeepers who recount and reify history (Prashad 2009, p. 121). Prashad notes that superficial diversity can exist beneath White supremacy, but "integration with resentment is not a community" (2009, p. 123).

Instead, Prashad advocates working toward transcending the resentment in part by understanding historical inequalities and their effect on the present, including on current (and often masked) systemic inequalities. Some of his suggested awareness-raising activities link local and global inequities. For instance, in "Geography of Fear," student and campus organizations (e.g., Women's Center, LGBT group, etc.) work from baseline campus maps indicating where crimes have been committed, and then map their perceptions of relative safety on campus "to transform the campus' self understanding of the geography of misogyny, racism, and homophobia. Who feels safe where, and what is the safety premised on?" (Prashad 2009, p. 126). In another activity, "Good Jobs," campus members ensure that Career Services promotes social justice and non-profit organizations as legitimate career paths: "If the career fair is basically a Corporate Fair, contest this. Also, most students tend to go toward money-making jobs because of the vise of student loans" (Prashad 2009, p. 126). One could add that motivation for high-salary jobs is also spurred by increasing university tuition costs, which in the U.S. have dramatically outpaced inflation for over a decade. Another awareness-raising activity is the privilege walk (McIntosh 1988, 1989). In one variation of this activity, participants line up side-by-side and are read several privilege prompts (e.g., "I was raised in a household wherein one or more parents had a college degree"). If participants' individual response is affirmative, they take a step forward, if negative, a step backward, and if their response is mixed or complicated, they can stay in place. I have facilitated this activity on my own campus and elsewhere, and although some participants may find it discomforting, it generally reveals a host of socially invisible and/or unearned privileges. Such activities provide opportunities for reflection on issues of *institutional and systemic* justice.

9.2.4 Guideline 4: Discuss Definitions of Social Justice

One of the most frequent questions from faculty is, "What do you mean by social justice?" The two most common missed opportunities in SJ faculty development contexts involve providing only one definition and not providing any. Giving one definition presumes that all the manifestations of SJ can be encapsulated in a single definition; by doing so, we lose the capacity to tailor SJ definitions to contextual particularities and nuances. Providing no definitions could be worse, especially in the hands of highly skeptical colleagues, who may pass off SJ as relativistic or irrelevant; by doing so, we lose the opportunity to meaningfully engage faculty in a serious discussion of what Riley has aptly described as the "contested and fluid" terrain of SJ definitions (2008, p. 1).

Alternatively, in faculty development workshops and other contexts involving some sustained discussion, it would be prudent to acquaint faculty with multiple SJ definitions, and even ask them to discuss which definitions apply most aptly to particular social justice contexts or scenarios. Faculty in one of our SJ workshops found the given definitions useful but inadequate and created hybrids, pulling concepts from some definitions and grafting them onto others. A sample of SJ definitions is provided in the Appendix.

9.2.5 Guideline 5: Unveil the Apolitical Myth

Proponents of SJAC are called to respond to another common set of faculty questions: Is SJ education forcing a political agenda onto students? Does SJAC politicize neutral or impartial ground? Meaningful, respectful dialogue to unveil the apolitical myth can remove a common source of faculty resistance to SJAC.

The apolitical myth is the idea that the classroom can be neutral or impartial ground, free of any guiding values. This myth has been unmasked by multiple scholars with several grounding principles, the most overarching of which is that, as scholar bell hooks has written, "no education is politically neutral," (1994, p. 37). To unveil the apolitical myth, two assumptions merit investigating: (1) The academy (and by extension the classroom) is neutral ground, and (2) apolitical pedagogy exists.

Whether the academy and classroom can be neutral ground has been called into question, for instance by Julia Alvarez. Born in the U.S., Alvarez is a Dominican-American poet, novelist, and essayist whose family was forced to flee the Dominican Republic when she was 10, due to her father's involvement with an attempt to overthrow the dictator Trujillo. Such experiences have made her attentive to issues of oppression and dominance. As Alvarez has noted, claims of neutrality often mask bias:

> There are those who worry that bringing such issues as social justice to the academy threatens to politicize neutral ground. That the value of academic discourse is in its impartiality…. In fact, the academy already has deep-seated and often unconscious biases that should be examined, discussed, held up to the light. [Alvarez then calls to mind Chaucer's Wife of Bath, who asks what a painting of a hunter slaying a lion might look like if it were painted by the lion.]
>
> What would an education look like that includes both the lion's and the hunter's points of view? In a pluralistic society, indeed a pluralistic world, how can education not do justice to this multiplicity [of viewpoints] if we are indeed preparing our students for their lives in this complex world? (Alvarez 2009, p. xxiii).

Also interrogating the bias behind claims of "neutrality," hooks notes that both including *and excluding* "the politics of racism, classism, heterosexism, and so forth that inform how and what we teach" remain political decisions. She provides the example of a white male literature professor who teaches only work by "'great white men'" (hooks 1994, p. 37). If that professor claims neutrality, it only masks the political decisions behind curricular content. An important issue in HSS curricula is to ensure a multiplicity of perspectives and provide opportunities for critique of them all. Kuecker also objects to a classroom "where professorial claims of objective positioning masquerade as thought but mask the highly subjective, political, and ideological nature of 21st century academia" (2009, p. 50). That masking sometimes happens via normalization, the process by which a once-new idea becomes a social norm. For instance, Kuecker points out that "community service and service learning are presented as objective social goods, void of ideology, politics, and subjectivity. Activist scholarship, however, is seen as flawed by the prejudices of the scholar, a betrayal of the sanctity of reason" (2009, p. 47). However, such perceptions constitute a judgment largely from the broad label of the pedagogy, not its particular intent, substance, or outcome.

The idea that the status quo is not objective or neutral, but just normalized, helps us investigate a second assumption—that apolitical pedagogy exists. Often "apolitical" pedagogy is presented as neutral. This myth of apolitical teaching is exposed by scholars who note that "…even [seemingly] apolitical active learning, such as hands-on discovery-based physics labs, has a connection to social justice, because one hope that lay behind the development of these approaches was that they would bring women and minorities to the academy and especially to science, to help them strategize to succeed" (Altman et al. 2009, p. 114). I added the word *seemingly* because that which passes for apolitical is frequently a manifestation of the political in normative garb. That is, whenever a set of political ideas is consented to by many as a worthwhile objective, it is no longer perceived as political but as a less visible social norm.

By contrast, whenever any set of political ideas runs counter to a social norm, it is marked as political. For instance, in 2011 some members of our campus hosted a presentation by a community activist who opposes mountain top removal/strip mining. Our administration asked that his presentation be counterbalanced with opposing voices, and as a result, the public talk was much more balanced, interactive, and dialogic. In some ways, this point-counterpoint format serves as a fine model for engaging campus discussions. However, no such format is required when presentations from corporate representatives occur on campus, which happen often. In fact, as one reviewer of this chapter noted, challenges to business and management discourses in engineering education practice (in the classroom, visiting lectures to campus, etc.) remain remarkably rare. The commitment to market-based problem solving and the idea that employability is the primary aim of engineering education are largely uncontested components of a dominant engineering discourse. As another example, when an instructor uses real data on human poverty to teach statistics, it can seem political, whereas using decontextualized, hypothetical data about "John" and "Bill" does not. However, in reality, both sets of ideas have political dimensions, even though only one may be perceived as such.

Why is this? One reason is that our own values tend to be invisible to us for the same reason that living in water is not remarkable for a fish. We inhabit these values, and often we have not had occasion to question them. That partly explains why we do not linguistically mark the norm yet mark deviations from it: as Goodman has noted, we might say "Latino businessman," "disabled lawyer" or "lesbian teacher," even when those social identities are contextually irrelevant, but we would generally not refer to someone as a "male president" or as a "white businessman" (2001, p. 18). Thus, SJ education remains an excellent opportunity to become aware of the (un)conscious biases and perspectives that inform our teaching and the content of our disciplines. In other words, SJ education can help us dispel the myth that teaching can ever be apolitical. Riley accentuates the distinction between often-invisible status quo values and the highly visible values that challenge the status quo in introducing her book *Engineering and Social Justice:*

> to claim that engineering is (or should be) objective is to presume a certain political attitude. Those who try to pretend that engineering is somehow objective and try to remove it from the political arena are themselves acting in a political way. Thus, I do not doubt that

> this book will also be labeled "political." But it is no less political than the profession of engineering and the practice of engineering education, although the ideas in this book may be less widely accepted in the mainstream (2008, p. vi).

It is possible, even plausible, that the apolitical myth, once unveiled, brings to light a more salient underlying issue: that as faculty, most of us are woefully unprepared to engage and integrate social justice issues into our disciplines and classrooms. This is in part because bringing "personal" or "political" issues into the classroom is still seen as violation of the "neutral" classroom myth. And perhaps more importantly, SJ education is fraught with inherent complexity. Hence, faculty development workshops serve as critical tools for SJ educators.

9.2.6 Guideline 6: Address Engineering Ethos Perceptions

All the guidelines described so far could extend to almost any academic context. But what about guidelines unique to *engineering education* contexts? This section addresses three specific ideologies observed in such contexts that could serve as sources of faculty resistance to SJ education: a technical-social binary, technological determinism, and functionalism. Collectively, these perceptions circulate within and inform the *ethos* of engineering education contexts.

9.2.6.1 Guideline 6a: Making the Sociotechnical Connection

Is most engineering work technical, social, or some combination of both? If both, to what degree is it technical and social? How do contextual circumstances shape our answers? Answers to these questions vary considerably among students and faculty in engineering education contexts. In the late twentieth century, scholars in Science and Technology Studies (STS) provided ample evidence that technologies are conceptualized, designed, forged, used, and improved in social contexts; social forces influence (and are influenced by) the processes and products of technology (Latour 1987; Latour and Woolgar 1986; Bijker et al. 1987). Yet a separation between the technical and social persists in engineering education contexts. That technical-social binary assumes technology occurs in a vacuum or is not meaningfully shaped by social forces (e.g., Hacker 1981; Faulkner 2000). Hence, from a technical-social binary perspective, technology is perceived as coming into existence devoid of social, political, cultural, ecological and ethical dimensions. As a result, linking engineering and social justice appears to violate the "clean" technical-social split. That split dichotomizes the categories so that technology is mentally associated with objectivity, neutrality, rationality, science, and the dispassionate pursuit of knowledge; by contrast, the social is associated with ideology, bias, error, subjectivity, politicized discourse, and more. So one crucial issue to address on the road to enacting SJAC is the consequences of this binary.

To many, especially those steeped in STS research, it may seem impossible that technology and social forces could be separated. Why would faculty be resistant to linking them? Faculty resistance to making the *sociotechnical* connection can emanate from multiple sources, four of which are noted here: disciplinary expertise, background knowledge, peer influence, and student expectations.

First, *disciplinary expertise* stems from the fact that higher education institutions have not traditionally aggregated scholars around serious sociotechnical problems but around disciplines. Whether we are conscious of them or not, as scholars, we inhabit disciplinary expertise bubbles; we often believe that breaking out of these bubbles would call our expertise into question. If scholars deviate from the ways of problem framing, perceiving, knowing, and problem solving in their discipline, various checks and balances exist to realign them with traditional disciplinary values—such as conference presentation feedback and peer review. Yet because the boundaries in which our expertise are allowed to roam are somewhat dynamic, they can (and should) be de- and reconstructed.

Certainly the *background knowledge* faculty bring to the classroom is shaped by our disciplinary education. For me and for most of my HSS colleagues, the technical-social binary played no role in our formal education. If we hold little to no background knowledge on how to make the sociotechnical connection, trying to make that connection in our own courses pushes us out of our knowledge (and disciplinary) comfort zones. From experience, we know that some faculty are reluctant to step out of such zones, even when they should. Thus, *peer influence* plays a role. If most of our disciplinary and other HSS peers maintain the technical-social division, those making the sociotechnical connection become social outliers. However, the inverse is also true: as more peers ask their students to investigate the consequences of the technical-social binary as it relates to course learning objectives in our HSS courses, an inertia begins that includes a growing storehouse of knowledge on texts, concepts, and pedagogical approaches to bridging the social and technical. For instance, in my own HSS division, we held faculty discussion forums with several colleagues on the ways in which we were integrating SJ education in our courses. In those discussions, three faculty who had co-designed a course on Engineering and Social Justice were able to draw from that course content to inform our fellow instructors about the basics of the technical-social binary. Other faculty then shared resources on SJ content and activities, drawing from STS and other HSS fields.

Finally, *student expectations* can shape faculty resistance. Those teaching in HSS programs to all or mostly engineering students know that some of those students perceive discussions of technology to be factual, impartial and objective, and discussions of social forces that shape (and are shaped by) technology as subject to bias, ideology, subjectivity, etc. Thus, when combined with the aforementioned three factors, a tacit or overt pressure is exerted on faculty to maintain the binary.

Clearly, these four sources of faculty resistance are mutually shaping influences. Collectively, they act together to create a blind spot among HSS (and other) engineering educators. However, the opposite can also be true—when the four sources work collaboratively to focus on integrating the technical-social binary into HSS curricula, the probability increases that students will begin demystifying the binary and making the sociotechnical connection.

Critiques of engineering education have been aimed at the propensity of *engineering* courses that reify the technical-social binary (e.g., Nieusma 2011; Chap. 4 by Cech, this volume). That reification occurs via the compartmentalization of social components of technology as considerations that are outside the purview of engineering. That separation could occur by explicitly marginalizing social considerations as of little to no relevance, by their omission in a course or curriculum, or by both. In either case, the message to engineering students remains the same: engineers focus on technical components, while the social aspects of technology are separate considerations that may or may not be part of engineering. For instance, in an editorial on why engineers should not consider social justice, the editor invokes social-technical dualism (Teschler 2010). He claims that if information—such as what constitutes social good—is non-quantifiable, it is outside the purview of the engineer (and often subject to manipulation by politicians). Such a broad stroke would exclude from consideration anything that is social, ambiguous, and/or difficult to quantify, regardless of how relevant it may be to an engineering project. Instead, he advocates for attention to measurable issues; as instances, he notes the relations between road types and traffic conditions as well as quantities and kinds of traffic. Yet these issues, however measurable, have significant social justice dimensions, such as where to site future transportation arteries vis-à-vis schools, residential areas, and more. (See Chap. 10 by Valderrama in this volume for an analysis of how quantifiable models used in public transportation systems have hidden social justice dimensions.) By creating a simple dichotomy between that which is quantifiable and can inform decisions about design alternatives and that which is nonquantifiable and thus deemed irrelevant, important questions are ignored:

1. Which hard data is relevant and irrelevant? Based on what criteria?
2. What factors does the data include and exclude? (For more on 1–2, see Stone 1997).
3. What happens when the same data leads informed engineers to different interpretations?
4. What should be done in cases in which some data is not (easily) quantifiable but the consequences of ignoring that data may be significant?
5. How might an interpretation based exclusively on technical factors be limited or even impossible?

One important aspect of maintaining social-technical dualism is keeping the social from "corrupting" the technical; this implies that the technical is pure, and all things social are somehow sources of impurity. In that sense, social-technical dualism perpetuates what Cech has called the "depoliticization of engineering,"

> the notion that engineering is a purely "technical" domain, and thus asocial and apolitical. Because science and mathematics knowledge is understood to be the basis of engineering expertise, engineering work is assumed to be carried out objectively and without bias.

> Indeed, this is the foundation of logical positivism, the belief that science and engineering work can be separated from messy "social" concerns as long as proper scientific and engineering methods of inquiry and design are followed….
>
> However, as decades of Science and Technology Studies research has demonstrated, even the most seemingly objective and neutral realms of engineering practice and design have built into them social norms, culturally-informed judgments about what counts as "truth," and ideologically-infused processes of problem definition and solution (see e.g. Knorr-Cetina 1999; Latour and Woolgar 1986; Mackenzie 1990; Traweek 1988)…. Indeed, the prioritization of certain "technical" features (faster, smaller, cheaper vs. quality or sustainability) over others are social and political choices at their core. Thus, the notion that engineering work can somehow be separated from the social world is *itself* a cultural frame for understanding what engineering is (Cech, Chap. 4 this volume, pp. 70–71).

Since engineering faculty are not alone in perpetuating the technical-social binary, an inverse critique is also warranted. HSS faculty frequently accentuate only the personal and/or social, failing to connect our work explicitly to the technological. That is, we often neglect in HSS curricula the complex forms of technical-social interplay. Thus, the technical-social binary is reified in multiple aspects of the curriculum, and engineering students learn to compartmentalize their education into technical *or* social, rather than sociotechnical. In this way, the HSS curriculum can become a mirror image of the technical engineering curriculum, wherein HSS emphasizes the social and the other the technical. As long as the technical and social chasm remains intact, engineering and social justice will remain separated.

9.2.6.2 Guideline 6b: Exposing Technological Determinism

What role does technology play in human progress? How we answer that question depends on, among other factors, our perspective on the technical-social binary. One perspective that circulates among some engineering students and even some faculty is *technological determinism*. For those espousing technological determinism, the answer to that question is that technology is the sole (or at least primary) driver of human progress (Volti 2008). If technology serves as the only or main driver of human progress and social forces, it behooves us to study technology, and social forces only become relevant insofar as they reflect the consequences of technology. By contrast, proponents of another perspective, the *social construction of technology*, argue the opposite: that "the emergence of particular technologies, choices between competing technologies, and the way these technologies are actually used owe a great deal to socially grounded forces like power, gender, and organizational ambitions" (Volti 2008, p. 304). Rightly, the latter perspective can be expanded to accentuate the idea that technology and social forces co-construct each another in mutually shaping ways (e.g., Taylor 1995).

Although technological determinism, social construction, and co-construction of technology may all circulate as part of cultural ideologies in engineering contexts, technological determinism tends to hold remarkable staying power. For instance, in 2008, the U.S. National Academy of Engineering (NAE) showcased its "Grand

Challenges," 14 salient challenges for twenty-first century engineering (National Academy of Engineering 2008). Riley (2011) has pointed out that the challenges are imbued with (among other ideologies) technological determinism. For instance, she notes that the NAE's description of the Grand Challenges includes the phrase, "Throughout human history, engineering has driven the advance of civilization" (quoted in Riley 2011, p. 4; NAE 2008). In this context, Riley says, "Innovation is presented as progress…[and] existing technology is passed over for the shiny new high-tech thing" (Riley 2011, p. 4).

Technological determinism is also a source of resistance to acknowledging the validity of linkages between engineering and social justice. If technology is a primary or sole driver of progress, social forces are only of interest in terms of how technology impacts them. So social justice issues can be relegated into those areas of lesser importance, holding less rigor and value. That is, for the technological determinist, social justice can become marginalized into a category of social forces that have little to no relevance to human progress.

Unless one is a student of STS, few opportunities exist in the curriculum to investigate technological determinism and other technological ideologies. However, making students and faculty aware of such ideologies can enable them to build more robust, defensible positions on questions of technology. It is also vital if we are to introduce why engineering and social justice are connected and merit curricular and cultural space in HSS and other areas of engineering education.

9.2.6.3 Guideline 6c: Exploring Perceptions of Social Organization

Along with the technical-social binary and technological determinism, another ideology circulates in engineering education contexts: functionalism. A recent study has investigated connections between views on social organization in engineering contexts and among functionalists (Leydens et al. 2012). Influenced significantly by sociologists August Comte, Herbert Spencer, Vilfredo Pareto, and Emile Durkheim, functionalism was the predominant theoretical perspective in sociology for a significant portion of the twentieth century. It has been defined as

> The analysis of social and cultural phenomena in terms of the functions they perform in a sociocultural system. In functionalism, society is conceived of as a system of interrelated parts in which no part can be understood in isolation from the whole…. (Theodorson and Theodorson 1969, p. 167)

When analyzing social phenomena, functionalists use a variety of metaphors to emphasize three primary elements: interdependence, equilibrium, and the self-reorganization principle. First, they highlight "the general interrelatedness, or interdependence, of the system's parts," (Wallace and Wolf 2006, p. 17). A common comparison is between social systems and the human body, which contains interdependent parts such as the respiratory, circulatory, and other systems. In addition to interdependence, functionalists accentuate "the existence of a 'normal' state of affairs, or state of equilibrium," (Wallace and Wolf 2006, p. 17). In fact, Comte described situations of social disequilibrium to be "pathological" (Wallace and

Wolf 2006, p. 18), and the concept of equilibrium came from the biological concept of homeostasis, which occurs when, for instance, one falls, scrapes a knee, a scab forms, healing occurs, and the body reaches equilibrium again (Wallace and Wolf 2006, p. 18). The final element is “the way that all the parts of the system reorganize to bring things back to normal” (Wallace and Wolf 2006, p. 17). Wallace and Wolf consider the analogy of any complex system, such as an airport, which can be thrown into disequilibrium by multiple variables, such as inclement weather, radar system malfunction, and high passenger volume, but that also have mechanisms for re-equilibration (2006).

Several conceptual alignments have been analyzed between functionalists and engineers (Leydens et al. 2012), and three such alignments will be briefly mentioned here: understanding of complex systems, notions of expertise, and meritocracy. Like functionalists, engineers are quite familiar with complex, interdependent *systems* (transportation systems, water systems, etc.). Thus, functionalism provides them with a familiar overarching view of society, and one to which they can contribute. Also, functionalists valued outsider and field-specific *expert knowledge*, deeming non-experts to lack the necessary background knowledge and detachment for objectivity; similarly, engineers tend to value objectivity, expertise, and scientific detachment, and devalue subjectivity (e.g., see Newberry 2007). Finally, functionalists believe in the validity of *meritocracy*; they had explained social stratification as necessary for incentivizing talented people to perform more socially valued (and rewarded) work: “Social inequality is thus an unconsciously evolved device by which societies insure that the most important positions are conscientiously filled by the most qualified persons” (Davis and Moore 1945, p. 243). In this way, social injustice is framed as an unfortunate but necessary byproduct of maintaining social function and order. Evidence from our work suggests that rationalizing injustice as an unfortunate but functional component of a well-oiled meritocracy occurs within engineering contexts as well (Leydens et al. 2012; see also Cech’s work on meritocracy (Chap. 4), this volume).[4]

The *ethos* of engineering education and the profession includes multiple interacting factors, a few of which have been explored here. Particularly in engineering education, it is crucial for SJAC proponents to understand the importance of addressing faculty resistance anchored in a technical-social binary, technological determinism, and functionalism.

9.2.7 Guideline 7: Acknowledge the Need for Pedagogical Innovation

A complete understanding of why SJAC necessitates shifts in the way instructors think about teaching and learning would merit its own chapter. In brief, since SJAC

[4]Our work also delineates conceptual links between conflict theory (which opposes functionalism) and social justice (Leydens et al. 2012).

pedagogies can challenge instructors personally, politically, and professionally, SJAC faculty development workshops should acknowledge and create safe yet challenging spaces for self-reflection, collaboration, and innovative pedagogical approaches (Skubikowski 2009). Fortunately, some particularly promising pedagogical research exists to help address sources of personal, political, or professional resistance to SJAC:

1. Goodman's research describes sociopolitical and psychological factors that lead to faculty resistance to SJ education as well also concrete methods of preventing or reducing such resistance (Goodman 2001, 2011). Preventing or reducing faculty resistance can also result from using the four-quadrant model, a heuristic designed for SJ initiatives to generate information and awareness of what students and instructors bring to the classroom as well as of course content and teaching methods (Adams and Love 2005, 2009).
2. Critical/liberatory pedagogies can help us re-envision how we think about our teaching and student learning (Giroux et al. 1996; hooks 1994; Freire 1993).
3. Threshold concepts have been applied across disciplines as a useful conceptual framework and metaphor for student learning as passing over a conceptual threshold (Meyer and Land 2006; Meyer et al. 2010). Such concepts also provide an excellent opportunity to recognize alignments between SJ concepts and typical course concepts and learning objectives (see Chap. 7 by Baillie and Armstrong's in this volume).

9.3 Conclusion

This chapter has proposed and described guidelines to address sources of faculty resistance to SJ education. These guidelines include one overarching guideline—to enact humility when connecting with all relevant campus stakeholders and constituencies, whether at the broad institutional level (such as those linked to accreditation, institutional leadership and culture), in faculty development contexts (where the apolitical myth and other salient resistance issues can be addressed), or within our own classrooms with our students. Three specific guidelines apply to faculty resistance within engineering education contexts, related to the ideologies of technical-social dualism, technological determinism, and functionalism. Each of these guidelines will require additional research in the form of empirical verification and critical reflection on the contextual complexities of implementation.

The guidelines contain both strengths and weaknesses. In terms of the former, the guidelines are general enough that they can be adapted to fit within the unique set of constraints and opportunities in place at each institution. Also, the guidelines are attentive to engineering education contexts, particularly guidelines 6a-c. However, the guidelines also contain weaknesses. For instance, they are by no means comprehensive in preparing SJ educators for SJAC initiatives. Also, as a flipside of the above strength, they remain general guidelines that do not indicate how to overcome local and sometimes seemingly intractable problems with SJAC implementation. Also, while writing the guidelines, I realized they lack three types of narratives. First, absent are narratives of faculty transformation in ways of seeing the role of SJ in teaching and learning. These narratives are both remarkable and inspiring in the uphill climb toward realizing SJAC. Another narrative form missing are those of faculty non-transformation. We need to learn from both why faculty do and do not transform their way of seeing SJ. Finally, narratives of "useful" faculty resistance are omitted. Faculty resistance can be grounded in ideas that help SJ faculty development workshop facilitators expand our ever-evolving conceptualizations of SJ. These salient challenges to the premises or conclusions of SJ education are to be ignored at our own peril. To dismiss all faculty non-transformation as a sign of closed minds is itself a form of closed mindedness.

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Appendix: Sample Social Justice Definitions

Barry argues for a fill-in-the-blank definition: The subject of social justice is the ________________ (fill in the blank) distribution among _________________ (fill in the blank) of rights, opportunities and resources that exist in a given society. Different perspectives fill in the blanks differently: for instance, from a feminist or civil rights perspective, the terms would be, "equal"… "men and women" or "blacks and whites" or "gay and straight." From a faith-based or Rawlsian perspective, "fair" … "rich and poor," etc. (Barry 2005)

"Social justice is concerned not in the narrow focus on what is just for the individual alone, but what is just for the social whole…. [T]he study of social justice includes developing an understanding of distributive principles (fair allocation of rewards and burdens) and retributive principles (appropriate responses to harm)…." (Capeheart and Milovanovic 2007, p. 2)

Social justice examines "the unequal ways in which social hierarchies sort difference to the benefit of some groups over others" (Adams et al. 2007; quoted in Bell 2010, p. 11).

"'Social Justice Work' is work that we do in the interest of securing human rights, an equitable distribution of resources, a healthy planet, democracy, and a space for the human spirit to thrive." —Innosanto Nagara, Co-founder DesignAction Collective (quoted in Riley 2008, p. 4).

“[after a longer definition] … It means that those of us who have privilege must be willing to give up those things that cannot be sustained in a fair world—especially those things that use an unfair percentage of the world’s environmental resources.”—Rick Ufford-Chase, International Director, BorderLinks (quoted in Riley 2008, p. 4).

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Part V
What Thinking about Social Justice in Engineering Practice Can Offer to Engineering Education

Chapter 10
What Can Engineering Systems Teach Us About Social (In)Justices? The Case of Public Transportation Systems

Andrés Felipe Valderrama Pineda

Abstract Politicians, consultants and engineers develop public transportation systems using a variety of well-developed and established modeling tools to calculate different aspects of a system. Some of them are performance-capacity against investment models to determine the value of a given technical choice. Others are economic models to calculate the feasibility of the system, the distributed benefits across population groups and the possibility of providing improved access to special users. These models are regarded as "rational" and thus morally neutral. However, recent research has demonstrated that the implicit assumptions and even the specific ways of estimating different constants to value input data in these models shape the results in ways that perpetuate social injustices built in the urban landscape of our cities. This chapter analyses the case of the design of Transmilenio in Bogotá, a public mass transportation system coined as one of the most progressive on the planet. Part of a political discourse to improve social justice in Bogotá, the project is successful in many respects but falls short of the original aims in many other respects. The chapter describes how the "rational modeling" brought in at various stages in the process hides social injustices under the veil of neutrality. This chapter, thus, calls to engineers to become critically aware of how they can influence systems modeling in ways that are more socially just.

Keywords Social justice • Engineering models • Urban transportation projects

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10.1 Introduction

A common image in many road crossings in Bogotá, Colombia's capital city, at peak hours reveals a number of passengers crowded in a bus that is stuck in a traffic jam. These passengers are tired, overworked and have no other choice than to take the bus to reach their homes or their work places. The bus is trapped in a traffic jam caused also by many cars. In each car one or two commuters are also tired and overworked, but sit comfortably while listening to the local radio or to their own music. Passengers in both the public bus and the private car can expect to have a long trip to reach their homes or their workplace in spite the fact that they live in a very dense city (Density in Bogotá is 4.311 inhabitants per square kilometer) (Kash and Hidalgo 2012), where actual commuting distances are very short compared to North-American standards.

Since 1997 the administration of the city of Bogotá has developed a new transportation system called Transmilenio (see figure below). The first phase of this system, which is generically known as bus rapid transit – BRT, began operation in December 2000 (Valderrama 2009). During the last 12 years two more phases have been developed. In the road crossings of Bogotá where Transmilenio operate you can still see buses crowded with overworked tired passengers besides cars where other more privileged citizens sit. The difference is the buses of Transmilenio run much faster because they have their own dedicated lanes, while private cars still have to struggle with endless traffic jams (Fig. 10.1).

Fig. 10.1 Transmilenio in Bogotá

From a social justice point of view, one could say that Transmilenio has inverted the conventional use of urban space where the wealthiest citizens rip off the benefits of public investments in infrastructure, while the less privileged have restricted and problematic access to infrastructure (Acevedo and Barrera 1978; Martens 2006). To invert this conventional use of space was the spirit and the intentions of the initiators of Transmilenio in Bogotá. Both mayor Enrique Peñalosa, who governed Bogotá from 1997 to 2000, and Ignacio de Guzmán, the head of the Transmilenio project, explicitly declared that public investment in the city should be directed primarily to the less well off at the expense of the wealthy. However, to achieve their political goals, Peñalosa and de Guzmán had to rely in a number of experts, including many engineers, and on expert knowledge in urban transportation.

In this chapter I will analyze how the political intentions of the city administrators of Bogotá where realized but at times were also betrayed through the design process of the Transmilenio system. The design of Transmilenio relied heavily on established knowledge in engineering and transportation and on practices of design of urban transportation systems, where engineers have a major role. Following Martens (2006), I will show how some technical models that are assumed to be "neutral," are actually based on implicit assumptions and models that perpetuate social injustices in the urban landscape of our cities. However, young entrepreneurial engineers, who become aware of the biases behind these assumptions and models, can successfully reframe and resist the power of established knowledge producing substantive innovation.

This chapter is organized as follows. First I summarize Martens' analysis of social justice and engineering in transportation models. Second, I present Peñalosa's discourse on what constitutes a socially just city. Third, I describe how the initial design team of Transmilenio challenged the established knowledge in transportation engineering. Fourth, I will show how engineers and economists struggled to model the city and the costs and benefits of the new system to demonstrate how the old public collective transport was responsible for the traffic crisis in the city, how the poor were the great beneficiaries of the system and how the special needs of users in wheel chairs couldn't be attended without risking the sustainability of the whole system.

10.2 Martens Argument

Karel Martens (2006, 2011) has been a pioneering researcher in discussing issues of social justice in transportation engineering. In this section I will summarize his argument, which serves as a valuable point of departure to indicate why and how the case of Bogotá is different. First I will summarize Martens approach to social justice. Then I will account for his criticism of transport modeling tools and cost benefit analyses. Finally I will refer to his proposed improvements to incorporate social justice considerations into the transportation and economic models used to make infrastructure investment decisions (Fig. 10.2).

Martens begins his analysis by pointing out that social justice has been much discussed in relation to environmental preservation and economic growth, at least in the US and Europe. Furthermore, he indicates that the bulk of the literature has placed emphasis on environmental issues at the expense of social justice. In fact, in

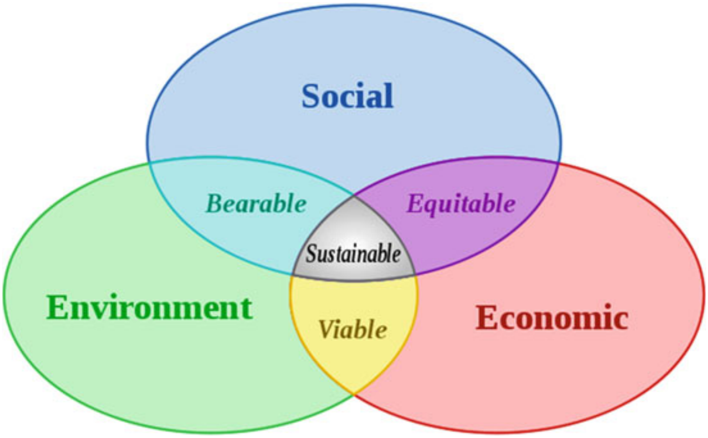

Fig. 10.2 The three dimensions of sustainable development (Source: http://en.wikipedia.org/wiki/File:Sustainable_development.svg)

the US there is substantial literature that analyses legislation in environmental justice: the distribution of environmental costs and benefits across populations(Chakraborty 2006; Forkenbrock and Schweitzer 1999; Lucas 2006). But, he indicates, that social justice in itself is not addressed substantially. To start correcting this void in the literature, Martens performs a social justice analysis of engineering and modeling tools. His working definition is that "social justice is understood here as the morally proper distribution of goods and bads across members of society" (Martens 2006: 3).

Martens foregrounding of social justice is appropriate for the Colombian context and the examples I am going to discuss in this chapter for two reasons. First, the design and construction of Transmilenio was part of a political project where social justice in itself was a strong element. Second, at the time Transmilenio was designed the environmental institutions in Colombia were still too young and weak, and thus environmental considerations did not have the preeminence they have had since the 1970s in the United States and Europe. Therefore a focus on sustainability only in environmental terms would not account for the real core of Transmilenio as a project (Fig. 10.3).

Martens' main criticism of transportation models is that they are based on the four step model (figure next page). This model is problematic "[f]rom a social justice perspective…[because it]… aim[s] to forecast future travel demand based on current travel patterns" (Martens, 4). If a model assumes that current patterns are the initial conditions then the model is going to project and propose a development that reinforces existing injustices and privileges. In Martens words "[t]his assertion implies that transport modeling that starts from current travel patterns may actually reinforce the existing differences in mobility and accessibility between various population groups." (Martens, 5). Additionally, if the models are conceived for cities and regions with high car ownership, when applied uncritically in cities and regions with low car ownership, they will introduce even more injustice.

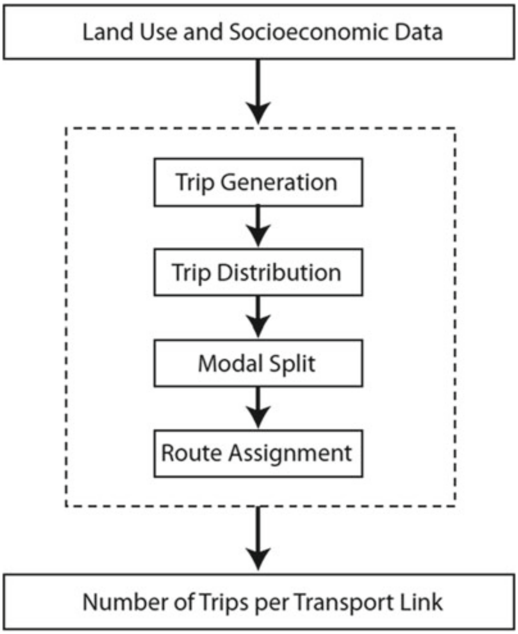

Fig. 10.3 The four step model

A preliminary analysis of the road infrastructure of Bogotá shows that it is much more developed and adjusted to a car-based society in the North part of the city, where the affluent classes tend to live, while in the South part of the city, where most of the working poor live, road infrastructure is precarious or outright absent. For example, in the south of the city there are neighborhoods where access to homes is only through pedestrian alleys. Thus, they were designed and constructed assuming that the dwellers of those houses would never have cars. I have no historical data to demonstrate that this has been the consequence of assigning investment based on transportation models. Yet in cities like Bogotá, it has been the case that infrastructure investments have been made in the absence of any sound modeling (Wright and Hook 2007). However, if future investments are made using the type of modeling criticized by Martens, the new investments will privilege the already privileged parts of the city (car owners) while castigating the poor parts.

Martens rightly points out that "by ignoring the fact that current travel patterns are a reflection of the way in which transport resources have been distributed in the past, transport models thus create an inherent feedback loop… This analysis can be translated into social justice terms. The fact that current approaches to transport modeling aim to forecast future travel demand suggests an implicit assumption that demand constitutes the just principle upon which to distribute new transport facilities" (Martens 2006: 6). The key concept in this analysis is demand. Most engineering students assume that demand exists independently and should be determined. But what Martens shows is that the demand is modeled in particular ways. And his critical point is that the generalized modeling of demand in transport assigns more weight to households that have more cars.

Table 10.1 Typical example of trip rates used in transport modeling

	Car ownership level		
Household size	0 car	1 car	2+ cars
1 person	0.12	0.94	–
2 or 3 persons	0.60	1.38	2.16
4 persons	1.14	1.74	2.60
5 persons	1.02	1.69	2.60

Martens suggests that a "social justice approach would focus on the distribution of transport investments over population groups and the related performance of the network for each of these groups." (Martens 2006: 7) Below I will demonstrate how the designers of Transmilenio not only attempted to distribute the investments in a more socially just manner, but also how they attempted to do it by design.

Martens also points out that some specific modeling of existing trip generation values differently the transportation needs of different households. A typical valuation uses a table like the one shown in Table 10.1.

This table is usually applied to a large set of data that represents the trip generation in a given urban or suburban region. As the reader can anticipate, the application of these valuations will produce a representation of trip generation that assigns more trips –and thus more need– to the locations where households have more cars, i.e., wealthier neighborhoods. In Bogotá, these neighborhoods are in the north of the city. Therefore, if investment decisions on infrastructure are made with this type of modeling, they will end up favoring the privileged at the cost of the poor. These decisions would be contrary to any public investment that takes social justice into account.

Martens also points out to the use of cost benefit analysis or CBA. This type of economic assessment is used extensively to evaluate the value of any investment for the society as a whole, but also its distribution among social groups. Martens main argument is that social justice considerations have traditionally played a role in the development of cost-benefit analyses, most notably in the monetary valuation of travel time savings. Since time savings typically account for the vast majority of benefits generated by a transport investment, the way in which the monetary value of these savings is calculated is of the utmost importance. In virtually all countries using CBA, the value of travel time savings is linked to wage rates, so the key question is which wage level to use in the calculation. The theoretical foundations underlying CBA suggest the use of market-based values and to differentiate the value of travel time savings according to differences in income levels of groups of travelers (Martens 2006: 10).

Again, Martens states that this type of valuation gives more value to the time of the privileged at the expense of the poor. Thus modeling investment in such a way will with no doubt give decision makers grounds to invest more where the privileged are located.

To correct this distortion, Martens proposes to use accessibility gains instead of time savings as the primary measure of benefit in CBA analysis. Accessibility gains refers to the fact that new road infrastructure, for example connecting a rich residential area with a wealthy employment area, is not translated into less travelling time for the mobility-rich. On the contrary, improved infrastructure means that they will have access to more places.

According to Martens, the identification of accessibility gains as the prime benefit of transport investments has profound consequences for cost-benefit analysis. The monetary value of accessibility gains is not related to income group dependent wage levels, but in large part to the existing level of accessibility of a person. More specifically, the value of an additional destination that comes within reach due to a transport improvement will depend on the choice set of destinations already within the reach of an individual. Following the principle of diminishing marginal utility, an individual with a large choice set of destinations may be expected to attach a lower value to the addition of an extra destination, than a person with a relatively small choice set of destinations, all else being equal. (Martens, 11)

Martens contends that taking accessibility gains as the primary measure of benefit tilts the balance in favor of the less privileged. These social groups are normally mobility-poor also. That is they cannot access as many places as the mobility-rich at a reasonable price. Therefore it is important to make new investments to improve the accessibility of mobility-poor citizens to new destinations (employment areas, health and education services areas, and so on). This might imply investments in public transport rather than in road development. Since accessibility gains will measure more for those with less access, then the application of this principle to CBA valuation will show that it is better to invest in those projects that improve the conditions of the poor instead of the rich. But all this depends on abandoning the idea that the time savings should be attached to income level.

Taking Martens analysis as the point of departure, I will now turn to the design and construction of Transmilenio in the city of Bogotá.

10.3 Bogotá and Transmilenio

From a social justice perspective the case of the design of Transmilenio is very interesting for various reasons. Most importantly, this transportation project was part of a political discourse in which social justice was explicitly central. Here I will present the general political discourse that supported the design of Transmilenio. Then I will show how the designers of Transmilenio resisted internationally accepted principles in transportation planning. Next, I will discuss how the economics of Transmilenio, and the transportation system it was aimed to replace, were developed in order to present Transmilenio as the best option. Finally, I will show how poor dwellers and the disabled were left out of the models used to design the system.

10.3.1 Peñalosa, Transmilenio and Social Justice: The Political Discourse[1]

Enrique Peñalosa became mayor of Bogotá in 1997 elected by popular vote. During his many campaigns (he had been campaigning for major since 1989), he always stated that transportation decisions had to be made according to a discussed and settled model of a city. He emphasized that transportation infrastructure, like all public space, should promote "igualdad" (equality) among citizens.[2]

Furthermore, during his term in office (1997–2000), he made a number of decisions that were consistent with his discourse: designing and building of Transmilenio; restricting circulation of private cars; establishing a *dia sin carro* (car free day) once every year; and conducting a referendum were citizens voted the complete banning of private cars at peak hours from 2015 onwards. During his period in office, the city constructed 300 km of bikeways and several green corridors of pedestrian-only roads. Towards the end of his tenure he even attempted the expropriation of two generous pieces of land in the North of the city, which were (and still are) used as private clubs. His idea was to convert these into public parks for the benefit of the whole city, not just of the privileged. At the time of his tenure only 29 % of the households in the city had cars and less than 20 % of the daily trips were done by private car. Therefore, according to him, any type of restriction to private car circulation was in favor of the majority of citizens who use public transportation. Or in other words, for 80 % of the citizens of Bogotá all days at all hours were non-private car days and hours.

Peñalosa has been an independent politician whose general political discourse does not necessarily clash with neoliberal ideology. On the contrary, his general discourse on improving living conditions in the city builds on the neo-liberal premise that it is only through increased international private investment that cities and countries will survive in a competitive global economy. Thus, improving the living conditions in the city was a way of attracting international investment. However, when referring to land issues, his criticism is clear as land issues are central to any discussion in transportation in cities. He states explicitly that in terms of urban land use, the market economy just does not work. In many developing countries, according to Peñalosa, landowners in urban areas can sit idle and see the value of their properties rise without doing anything. That happens because they rip off the benefits of the general community, whose activity is what increases the value of the land in the entire city. Therefore, he proposed that within the borders of the city, and even in neighboring areas, the state should set strong regulations, and even expropriate

[1]This account of the political discourse is based on interviews by the author with Enrique Peñalosa conducted the 15th of October of 2005, with Ignacio de Guzmán conducted the 10th of March of 2009 and with Germán Lleras conducted the 10th of February of 2010. All the interviews took place in Bogotá.

[2]These ideas were not new for Peñalosa as he had been developing them in various former positions. For example as Secretary of the United Nations Habitat meeting, he wrote an outline of these ideas already at the beginning of the 1980s (Peñalosa 1976, 1979, 1982).

areas to allow for a reasonable growth of the city with an adequate balance of residence areas, green parks and areas for the creation of jobs. In particular, his criticism has been directed to the owners of the nice flat lands to the west of the city, whose private ownership has limited the growth of the city. As a consequence, poor immigrants from rural areas have settled in the steep slopes of the neighboring mountains to the south and the southeast of the city. The difficult geography of these areas makes the provision of transportation (and many other services) more complicated and costly for the dwellers themselves and for the city administration of Bogotá.

Ignacio de Guzmán is a Colombian lawyer and entrepreneur who became the right hand of Peñalosa during his term in office. De Guzmán headed the team of engineers and experts that designed Transmilenio. For de Guzmán "real democracy" was about creating good public space for all citizens. For him streets, roads, sidewalks and parks were not only meeting places, *but foremost places were we all have equal rights*. Additionally he strongly believed that a general democratic principle states that those with more resources should contribute accordingly more to the public treasury. But that the expenditure of the public budget should be directed to favor the less privileged, the most vulnerable, in the first place. In terms of investment for transportation in Bogotá, thus, it was clear for de Guzmán that the resources should be used primarily to upgrade and improve the public transportation system (which is used by about 80 % of Bogota's population). For him, there should also be investment that supports private motorized transport, but as a secondary priority.

De Guzmán developed a general criticism of private motorization. He stated that people that owned cars and paid more taxes, felt they had the right to demand appropriate road infrastructure. But in turn, he said that general democratic principles demanded that the State reminded citizens that their rights to drive (which includes being awarded a driving license) and use public space were regulated by the State, and that those rights were not natural, but should be regarded as "precarious" rights, i.e., awarded according to the availability of resources. Therefore he promoted the development of a physical infrastructure for Transmilenio where private cars and public buses had the same access to the infrastructure. In the Avenida Caracas, the largest thoroughfare crossing the city from one end to the other, for example, his philosophy translated into the development of a road in which the public transportation system had two exclusive lanes, while private cars had also two lanes, in each direction. In technical terms this was translated in improved speed and travel time for those using the public transportation system at the cost of those using the private car. But in other parts of the city, Transmilenio only has one lane, while private cars have three, four or five lanes. These were developed after Peñalosa and de Guzmán left office. De Guzman criticizes this design because it betrays the general democratic spirit outlined above. In those roads, he claims, the promoted relationship was reverted as public investment was used to favor primarily the users of private transport at the expense of the users of public transportation system (Fig. 10.4).

In short, both Peñalosa and De Guzman, along with the general administration of the city at the time, developed a political discourse for the city in which social justice was a central element. But was this discourse realized or betrayed at different stages in the design of Transmilenio?

Fig. 10.4 Pictures show two lanes for transmilenio buses and two and three lanes for cars

10.3.2 Resisting General Transportation Principles

Germán Lleras is a Civil Engineer who specialized in transportation early in his career. Just 2 years after graduation he became one of the first members of the design team of Transmilenio in 1998. In the initial stages of the design, the engineers in charge of the transportation engineering of the project developed a mathematical model to calculate the capacity of a bus-based mass transit system. This modeling was supported by Brazilian transportation experts and by the existence of a previous experience of assigning dedicated lanes to public buses in Bogotá. When Lleras and his colleagues attempted to validate their results with European consultants they faced a big surprise.

As I have written elsewhere, french bus operators from Connex came to Bogotá at the end of 1999. They were invited by the local engineers working the transit details of Transmilenio at the headquarters of the project in the historical city centre of Bogotá. When the Frenchmen saw the figures of the amount of passengers to be transported, the layout of the city and the expected timing of the operation they were in disbelief. They scorned the Colombian engineers' mathematical models and forwarded a proposal: "to achieve that transportation capacity you need a metro system and we are the ones to design it for you." With utmost patience the Colombian engineers took the French consultants to the busiest crossing in the city: Avenida Caracas with 76th street so they could 'see' that the calculations were not unreal. After this, the French acknowledged that bus systems 'could achieve' transportation performances similar to that of metro systems. Connex eventually became one of the investors in the new Transmilenio system (Valderrama and Jimenez 2008).

Probably the French engineers were operating within a technological framework (Bijker 1995) that states that any type of system based on buses has a limited capacity. Below is a figure that plots investment against capacity used by renowned transport

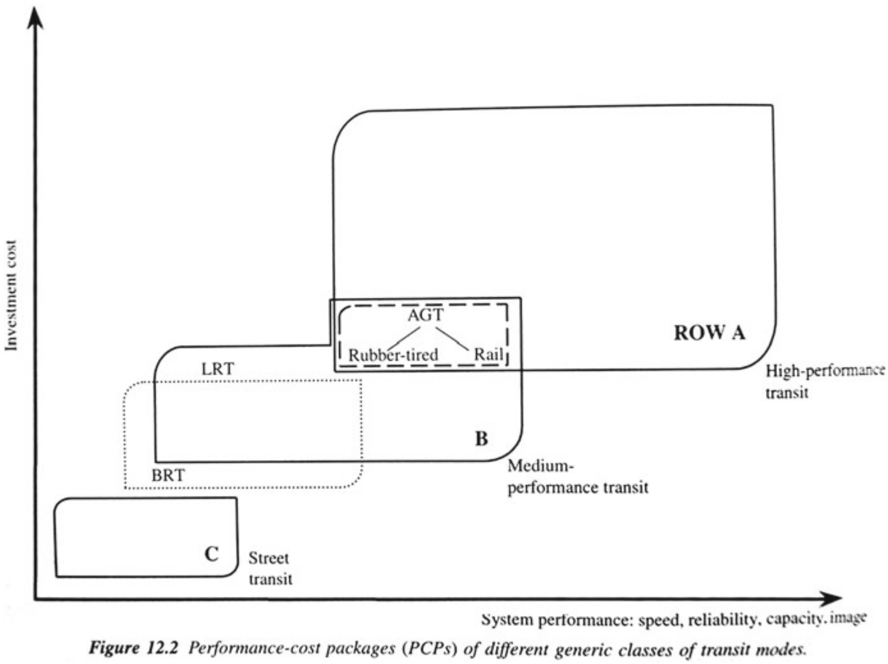

Fig. 10.5 Diagram of performance-capacity against investment costs of various transportation modes as it appears in Professor Vukan Vuchic's book urban transit systems and technology (2007)

planner Vukan Vuchic from the University of Pennsylvania whose books are widely used in education and research all around the world. This graph specifically states that even bus rapid transit (BRTs) systems have limited capacity. Note for example how this chart states that BRTs can barely compete in performance against heavy underground rail systems (Fig. 10.5).

In contrast, politicians, consultants and engineers engaged in the promotion of BRTs around the world, have consolidated during the last 10 years measurements to propose a different general modeling of investment against capacity. As shown in the figure in next page, according to their measurements BRTs can in fact compete in capacity with heavy rail systems, with the huge advantage that the investment costs are significantly lower. If this tension between existing established knowledge in transportation engineering (Vuchic 2007) vs emerging alternative knowledge (Wright and Hook 2007) was still strong in 2007, in 1997, any transportation expert advocating for the benefits of BRTs was clearly challenging the status quo. That is why the French engineers felt so sure in their criticism of the Colombian and Brazilian engineers' calculations (Fig. 10.6).

In terms of social justice in engineering what we see, then, is that the Colombian and Brazilian experts were facing the weight of established modeling in transportation engineering in 1997. If Colombian engineers accepted this knowledge, the city administrators had no other option than to accept the French assessment of the situation and start planning for the construction of an underground metro.

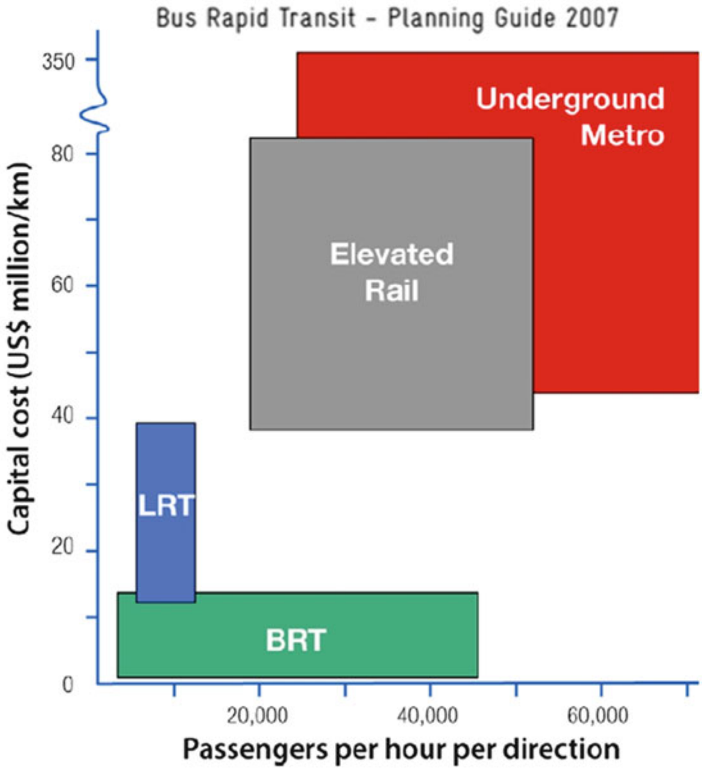

Fig. 10.6 Diagram of capacity against capital costs as it is presented in the bus rapid transit – planning guide (2007)

However, Peñalosa, de Guzmán, Lleras and many others had discarded that option after serious consideration. The reason was simple: a Metro was (and still is) too expensive for a city like Bogotá and takes several years to be designed and constructed. The investment needed for a metro would limit the city's investment capacity in other areas like education, health, housing and public services. Therefore Peñalosa, de Guzmán, Lleras, and the rest of the collaborators and supporters, took the risk of pushing ahead with Transmilenio, in spite of the fact that it contradicted established knowledge in transportation: it was the only way of producing an economically sustainable transportation system for Bogotá and improving the mobility, especially for the users of public transportation.

Thanks to the success of Transmilenio in Bogotá, and the resistance of Bogota's policymakers and engineers to previously established knowledge, BRTs have become increasingly accepted as a possibility for cities to develop high capacity transportation systems at low cost (Wright and Hook 2007). This issue is important in relation to social justice. If the only way to achieve mass transit capacities is by making huge investments in rail solutions, then many cities in the world cannot afford these. Because most cities in the world are not wealthy and cannot afford the investment required, the development of a BRT alternative is very much welcomed. It is not a surprise then that by 2010 more than a 100 cities in the world have engaged in the development of one or another type of BRT.

My point here is that models belong to communities of practitioners, in this case to transportation engineers. If those communities choose to believe un-critically in their models then they might be promoting a knowledge that produces social injustice. In other words, if they choose to believe that reality should adjust to the models, rather than the other way around, they might be incurring in what the Jamaican-American philosopher Lewis Gordon terms "disciplinary decadence" (Gordon and Gordon 2006). Disciplinary decadence is the belief that reality should adjust to our theoretical conceptions of the world. Therefore, if transport planners believe that Vukan Vuchic's graph of capacity vs. investment is an accurate model of how different transportation systems perform, then they might give up the idea of producing new high performance systems like Transmilenio. This is what the French consultants did in our case here. On the contrary, if transport planners are critical of Vuchic's model, they might produce a new system like Transmilenio, and in doing so, they will show that the model could be further adjusted to fit with reality. That is what our Colombian and Brazilian planners and engineers did back in 1997–2000.

10.3.3 Social Justice(?) of Transmilenio I: Framing Public Transport Owners and Drivers as the Bad Guys

During the years that preceded the design and construction of Transmilenio, numerous economists and transport analysts developed a model to frame what they considered to be the most pressing problem of Bogota's traffic: the *transporte público colectivo* TPC (public collective transport).

Figure 10.7 was developed by Edgar Sandoval, first CEO of Transmilenio S.A. and used since his days in office, and then through out the last 10 years as international consultant. The model explains how the *Guerra Del Centavo or* "cent war" was structurally framed. The "cent war" is commonly known as bus-drivers' hectic behavior when competing to collect as many passengers as they can. During this "war", drivers do not stop at designated bus stops but wherever and whenever potential passengers signal a bus to stop, picking up more passengers than those allowed by the capacity of the bus, shifting lanes without signaling and often speeding up and breaking violently.

The model explains this behavior as follows: in an ideal relationship (depicted by top row of ellipses) the State provides the infrastructure for transport companies to provide a service to the population. In turn, the population pays a fee for the service and transport companies pay the state taxes on their income. In many countries, transport companies are public, but they can also be private. Regardless of their status, transport companies are providing a public service and thus should assume all administrative and civil responsibilities associated with transporting people.

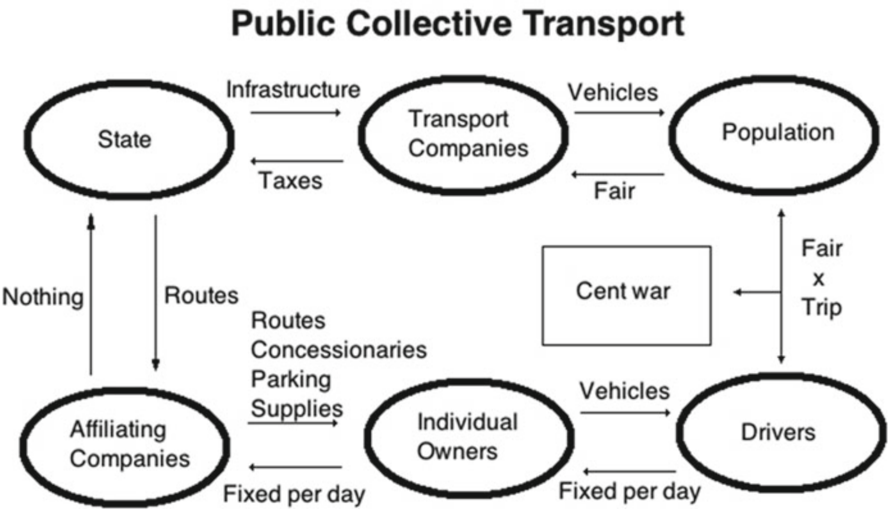

Fig. 10.7 Model of the traditional collective transport system

However, as the model shows, since the 1920s when the first buses began operation in Bogotá, a different model slowly developed (Castañeda 1995) resulting in the situation that is modeled in the ellipses of the bottom row the figure above. The state provided the infrastructure for transport and gave transport companies the right to administrate assigned routes in the city. Instead of providing the service, transport companies (or better *affiliating* companies) allowed bus owners to affiliate their buses to their company. This means that transport companies did not own the buses. They just charged bus owners for the right to provide a service in the route assigned to the transport company. In turn, bus owners had to pay a fixed daily fee to the affiliating company. Bus owners then hired drivers to provide the service. Drivers provided service and collected income at the same time. Passengers paid a fixed price regulated by the city administration. At the end of every day, the driver had to pay the owner a fixed amount of the daily income; he could keep the rest for himself. This loose arrangement had the consequence that in practice most of the administrative and civil responsibility was in the hands of the driver. Bus owners had to maintain their buses and nothing else. And transport companies had only to defend what their perceived as their right to administrate routes. According to the model, companies could generate income without doing much.

One would think that transport company owners then were making a fortune without doing anything. But what the model does not show is that the property of the whole TPC was highly distributed. Unlike other public services in Colombia,[3] public transportation was distributed in Bogotá among 68 transport companies, more than 25,000 bus owners and more than 20,000 drivers. The reason for having more owners than drivers is that some buses were own collectively by several small owners.

[3]In Colombia and many other countries there is a high concentration of property in some services. For instance, mobile telephony in Colombia was owned at the time by only two companies and a one minute call was as expensive as a single ride in public transportation.

Bus drivers made at the time as much as four times the minimum wage in the country. They earned more than taxi drivers and had flexible working hours (although they indeed tended to overwork to maximize their income). However, they were pictured in the model above as the great victims of the TPC, being exploited by bus-owners and transport company owners. It is true that in case of an accident, the bus driver held full responsibility. But it is also true that they had a reasonable income in a country were almost 60 % of the population does not have a formal employment. They were at the top of the pay-scale among those involved in pay per day work.

In short, the model above presented TPC in very negative terms. It mainly pictured transport company owners as the bad guys because they had all the privileges and no responsibilities. Drivers were also depicted as bad guys, mainly because they were the last link in an exploitative system. They were the victims of the TPC organization. The model also signaled that lack of professionalism was due to exacerbated competition that was derived from having too many drivers, bus owners and transport companies. So how was Transmilenio supposed to improve the way in which the citizens of Bogotá should receive public transportation?

Transmilenio was heralded as the right way to provide public urban transportation service because it addressed all the flaws of the TPC. Transmilenio S.A. was constituted as public agency with responsibility over the service, while the operation was granted to *a few* proper transportation companies taking all the responsibility for owning the fleet and hiring properly trained bus drivers and all support personnel needed. The process of constitution of Transmilenio S.A, and the system in general, resulted in a concentration of property in the hands of few companies with the capacity to provide the service and comply with the strict regulations set in place with the design of Transmilenio.

10.3.4 Social Justice (?) of Transmilenio II: Framing the Poor at the City Margins as the Great Beneficiaries

Transmilenio proponents and designers claimed that the greatest beneficiaries of the system would be the poorest citizens who live in at the margins of the city. Bogotá has grown during decades in a very disorganized manner. Poor immigrants from around Colombia normally settle in legally, illegally or semi-legally owned or rented small pieces of land in the borderlands of the city. One of the greatest advantages of the TPC was its ability to attend the transportation needs of the new settlers. To put it in colloquial terms, as new neighborhoods popped up constantly, there were always transport company owners, and their network of affiliated bus owners and drivers, willing to exploit that "new market". The authorities of the city could barely regulate that pace of growth and issued authorizations for the operation of the new routes quite easily (Castañeda 1995; Valderrama 2009).

However, some of the new neighborhoods were developed in mountainous places were access by buses was difficult. In these places small fleets of jeeps and small commercial vehicles provided a “feeder” service, taking passengers to the nearest street where normal public transportation was available. Therefore, poor settlers living in the most remote places had to take two or even three vehicles to reach their destinations within the city. The designers of Transmilenio developed a system with few high-speed trunk lines along the main corridors of the city, and extensive feeder routes in the end of these trunk lines. These feeder routes were projected to cover the most remote places bringing the passengers to the main lines *at no additional cost*. So the great incentive of Transmilenio for users at the margins was that they were going to pay *just once* for a trip which before required two or three payments. These projected benefits were fed into economic models showing how the poor were going to be the great beneficiaries of the Transmilenio system.

What the authors of the models did not consider was that the local “jeep-feeder” fleets and the TPC drivers in general gave all sort of discounts on an ad hoc basis. Recently Kash and Hidalgo (2012) have surveyed the practices. Their results show that especially mothers with children are the great beneficiaries of the ad hoc discounts given by TPC bus drivers. That is a mother with two children coming from a remote place might have to pay two times her fare to get into a jeep and then the bus fare in the city. The children would ride for free. In Transmilenio, they all have to pay only once, but they have to pay three tickets, with no discount for children. So the models used to demonstrate the distributed benefits of Transmilenio were based on assumptions that did not correspond to reality.

10.3.5 Social Justice (?) of Transmilenio III: Framing Vulnerable Citizens as Threats

On 28 February 2001, Colombian disabled citizen Mr. Daniel Arturo Bermúdez Urrego sued Transmilenio S.A. for not guaranteeing him access to the transportation system. Bermúdez used the legal instrument *tutela*, which was established by the country’s constitution of 1991. This legal instrument allows individuals to sue other individuals, organizations or the state itself, if their fundamental rights are violated. Mr. Bermúdez argued that Transmilenio S.A. had implemented only partial accessibility to people with disabilities. Although access was guaranteed in the trunk lines, a feeder route that passed very close to his home had no devices to facilitate access for persons in wheelchairs, like him. Consequently he had to travel in his wheelchair 15 blocks through a hostile urban built environment to reach the part of the system where he could actually have access. His argument was supported by various laws, decrees and technical norms developed during the 1990s, which mandated the provision of access for people with disability to all services, including transportation (Cepeda Espinosa 2002).

Transmilenio S.A. argued that the transportation system was composed of two different technologies: the trunk lines with new buses, new stations and all the devices to facilitate access; and the feeder lines, which had only to comply with the requirements for the traditional Transporte Públic Colectivo – TPC (Public

Collective Transport) as set by the Ministry of Transport. Transmilenio S.A. also argued that the agency was pursuing a program of improvements to comply with the law, but that the costs of full access threatened the economic sustainability of the system as a whole, and that increased costs would imply higher prices for all passengers (Cepeda Espinosa 2002: 4). A judge ruled in favour of Transmilenio S.A. on 15 March 2001, arguing that transportation companies should proceed to develop full access, but through a technically and economically sound process, and that such actions should be exempted from the peremptoriness of legal actions like the *tutela* (Cepeda Espinosa 2002: 5).

Mr. Bermúdez did not accept the decision and filed an appeal at Colombia's Constitutional Court. The court magistrates considered the case and ruled in favour of Mr. Bermúdez on 1 August 2002. The court interpreted the situation in the following juridical terms:

> Does the company in charge of the management, organization and planning of the transport service in a city ignore the right to equality, liberty of locomotion and protection of a special person who lives in a marginal area, and who uses a wheelchair because of disability, and who does not have access to transport because of his condition? (Cepeda Espinosa 2002, translated from Spanish by the author).

Magistrate Manuel José Cepeda Espinosa developed extensive argumentation, bringing in examples of diverse sectors to demonstrate that despite the fact that legislation and technical norms are still in the making, the public company Transmilenio S.A. should guarantee access to the feeder lines to disabled passengers. This should be accomplished by the immediate installation of several elevators in feeder bus units (Fig. 10.8) and through the development of an access plan in a period no longer than 2 years. Transmilenio S.A. was also obliged to report progress every 3 months to the *Asociación Colombiana para el Desarrollo de las Personas con Discapacidad* ASCOPAR (Colombian Association for the Development of Persons with Disability) (Cepeda Espinosa 2002: 33).

It is striking that while in other cases the administrators of Transmilenio S.A. were willing to defend the social justice principles that supported the system, in this case they did the contrary. Their argument was supported on the fact that Transmilenio is based in a technical tariff, where the prices of the trips are governed by the actual operation costs. If operation costs increase, prices will increase for all passengers. Therefore, in the design of the technical tariff administrators assume that it is the final passenger is who takes the burden for increased costs for any reason. Although, one could argue that in rejecting the claims of people with disability Transmilenio's general manager was acting in the best interest of all abled passengers, his actions were actually framed by a technical tariff,[4] and other funding possibilities, such as city subsidies, were not taken into consideration.

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[4]The price for using Transmilenio is not decided politically in the city council, like it was with the TCP. It is now determined by a formula (a model) that takes into account the costs of operation of the system. Therefore, it the operation costs increase, so the price of the ride. Therefore, it can be said that the economic model of Transmilenio was designed in such a way that most of the economic risk of the system is handed down to the passenger.

Fig. 10.8 Elevator in a feeder bus. Presentación general transmilenio (Power Point). December 2008

10.4 Implications for Engineering Education

The case of the design of Transmilenio has many sides and is very interesting from many other points of view (Ardila 2007; Echeverry et al. 2005; Lopez et al. 2011; Moller 2010; Valderrama 2011; Valderrama and Beltran 2007). However, how are these reflections on the use of models and social justice of general interest to other areas of engineering practice and education? How could an improved education of engineers incorporate discussions of social justice and environmental issues as an integral aspect of the training in modelling tools?

As we move into the second decade of the twenty-first century and despite repeated calls (National Academy of Engineering, NAE 2005) and experiments to educate a new kind of engineer, mainstream engineering education still assigns the greatest value to the technical subjects in which students work endlessly with mathematical problems and models. The typical engineering education program still exhibits a technology and society divide in its curriculum: the technical aspects of technological systems are taken up by regular courses offered by the engineering school and are central to the engineering curriculum and it is here and only here were engineering students approach modelling tools. All the social, environmental and ethical issues related to their engineering training are normally relegated to elective courses offered by liberal arts units or their equivalent (see Cech's Chap. 4 in this volume for a detailed critical analysis of the split between "technical" vs. "non-technical" curriculum).

To train engineers to deal with all the technical and social justice challenges shown in the analysis of Transmilenio, what is missing in most engineering education programs is a more balanced and thorough integration of the social and the technical in a same training activity. There are different levels of integration that could be achieved according to the level of ambition of its promoters and the availability of resources and support from engineering schools. The most basic level of integration can be achieved in a single course. The most complete integration would cover an entire engineering program. I will provide examples and references of the two. In between there is a whole range of possibilities from multi-course integration to special project semesters or sequence of semesters. For the sake of brevity I will concentrate on course and whole program integration.

10.4.1 Course Integration

A typical engineering course to train students in modelling tools will normally concentrate in developing the students' competencies in the *use* of these modelling tools. Depending on the level of complexity of the tools, students will use most of their time understanding the logics of the model and performing various exercises in order to become accomplished users of any given model. Questions related to the criteria of when to use a model, how to adapt it, and even for the limits and implications are normally left out or taken up just briefly in an introductory class. More interested educators might have one or two visitors "from the real world" to share on-the-job stories about the use of one or another model.

But are there examples of teachers' developing more integrated training of modelling and models in their courses? One example of this integration is exhibited in Professor Joseph Sussman's course Transportation Systems at MIT. In this course, Professor Sussman not only teaches the students about transportation modelling tools but most importantly he teaches the students to think about when and how to bring in modelling tools to support the decision-making process in a real life situation. This means, that students need to think not only about technical transportation challenges, geographical data and travel behaviour, but also about resource availability, interaction with politicians and institutional determinants (http://ocw.mit.edu/courses/civil-and-environmental-engineering/1-221j-transportation-systems-fall-2004/index.htm).

Professor Sussman is an experienced transportation engineer after decades of work in the area as consultant and expert. What he is attempting to do in this (and other courses) is not to leave his extensive experience outside the classroom. Nor he will bring it in only as "war stories" to spice up the "real training" of students in the use of transportation models. What Professor Sussman has attempted to do is to theorize from his experience in order to provide students with a more accurate picture of what happens in engineering practice. This is the whole motivation behind the development of the Complex Large Integrated Open Systems (CLIOS) framework. The framework proposes a basic three-stage design process, where engineering students pick up a system, decide on an improvement, analyse its possibilities and propose an implementation plan. The framework stimulates iteration to consider fully the consequences of different choices. Specific methods and models can provide valuable information at different stages in the process, but the framework is explicit about the limits of each model. The CLIOS framework and the way it is deployed in courses is an attempt to integrate the social and the technical in the training of students. However, these efforts are limited to a course level.

To exploit the limited resources of a single course, I suggest that engineering educators might profit from the development of case studies. Cases are extensively used in the education of lawyers, administrators and economists. They might consist of real stories of engineers taking up a project like the design of Transmilenio. The teachers might use the case study to present to students the possibility of discussing and analysing the choices made by the designers at different stages in the process. This entails a strong change of attitude: instead of seeing mathematical and computing models as a way of short cutting social complexity and saving time in the analysis of data and alternatives, engineering educators teach students to understand that the models do not replace judgement. Engineering educators need to understand that using time teaching when it is appropriate to use a model, how to adapt it to a specific project and analyzing the consequences of results after using a model are all integral and crucial aspects of educating engineers.

10.4.2 Whole Program Integration

To my knowledge two programs stand out as examples of engineering education programs that integrate structurally technical, aesthetic and social aspects in the design of products and systems. They are: the Design, Innovation and Society program at the Rennselaer Polytechnic Institute in the United States (Nieusma 2008); and the Design and Innovation program at the Technical University of Denmark (Jørgensen and Valderrama 2012).

The promoters and supporters of both programs have conducted a complete restructuring of the engineering education program template. This means that they re-designed the whole structure of the program, and the content of almost all the courses involved in the program. The challenges faced in each institutional setting were different, but both teams of academics faced the need to overcome the stringent conditions ossified in institutions like the credit system, the requirement of courses to be independent units to fit in all sorts of places in the curricula and the contradictory requirement for courses to be at the same time more generic, more elective and more fundamental.

The first significant departure from traditional engineering-science based curricula made in the two programs is to structure them around design studios, the backbone of these programs. Each design studio has an academic burden for students that is equal to two or three courses (9 credits in the US, 15 ECTS in Europe). They involve several faculty members with different backgrounds. And they are project based. It is around the development of a project that the students bring in rigorous social, technical and aesthetic analyses. Both programs are structured around eight consecutive studios.

In both programs the fundamental courses in mathematics, physics and engineering sciences still exist and students have to take them to graduate. The difference is that these courses are not the structuring core of the program. It is the design studios where the integration of knowledge happens. In both cases, the students develop a capacity to integrate different knowledge in order to produce a working product or system. There are at least two overarching pedagogical strategies deployed in the design studios. The first one is conceiving objects as parts of complex systems. No single product or service stands alone. They are all part of intricate, complicated and complex social and material systems. Therefore any single technical decision has social consequences and all social considerations have implications for the technical decisions. The systems are, thus, socio-technical.

The second strategy relates to the approach of viewing technical systems as what they really are: socio-technical systems. A new challenge emerges here: How to deal with the complexity of a socio-technical system when teaching engineers? The answer is through *directed oscillation*. In any type of problem, whether is traffic, communication or medical technologies there are at least two dimensions to consider. On one hand there is the tension between the object to be designed and the socio-technical system to which it will belong. And the second tension is between the problem to be addressed and the solution chosen. In both dimensions there is a tension between the concreteness of the design task and the complexity of the context.

Take as an example the case of Transmilenio. The designers of Transmilenio had to deal with the concreteness of diesel engines, traffic lanes, passenger loads, vehicle manoeuvrability, physical access of able and disable persons to stations and buses, emission regulations and so on. And they also had to deal with the complexity of the political system of Colombia and Bogotá, the institutional obduracy of the public collective transport and even the inertia of established knowledge in transportation engineering. When they took decisions about how to model the system, how to design it and so on they were oscillating between the materialities of the design decisions and the social context that determines and is determined by those decisions. Designers were also oscillating between solving a transportation problem and creating a new city as a whole. Different disciplines were brought into the task: urban planning, transportation engineering, thermodynamics, passenger behaviour and so on. This same oscillation is brought into the classroom and directed by the teachers in the design studios in order for the students to approach the different aspects of their design task (Nieusma 2008).

Educators at RPI have also introduced special attention to marginalized groups in their design studios. Through this pedagogical strategy they have been able to bring into the design task a reflective element as to how technical decisions are shaped by social relations and how in turn these relations are also shaped by designed objects and systems. In other word, they can study how existing designed systems and objects have a role in socially unjust arrangements and how these could be re-designed to address these issues along with the technological, economic and environmental challenges that all systems pose (see Nieusma's Chap. 2 in this volume).

10.5 Conclusion

In this chapter I have examined how engineers and economists made decisions about the design of Transmilenio. The project of designing a new transportation system for Bogotá had a progressive discourse in social justice as a core element. However, as engineers and economists made decisions, they faced several challenges. First, they had to resist a technological framework of established transportation engineering theory according to which high capacity was only possible through the construction of expensive heavy rail systems. Facing this challenge, the designers of Transmilenio successfully prioritized the core social justice principle of the project, namely to use public investment to produce high quality in a public transportation system where the citizens of Bogotá could meet as equals and whose time savings were privileged over those of car users. Thus they resisted established knowledge, which implicitly required investments that were beyond the financial capacity of the city. In doing so, one could argue they produced a socially just innovation in both technological and social terms, i.e., techno-social justice.

However, further in the process one can see that the application of economic models to develop Transmilenio falls short of social justice core principles. I have shown, how Transmilenio designers framed the TPC owners and drivers as the "bad guys." In terms of stakeholder inclusiveness (procedural justice) in the transportation business, it is not clear that Transmilenio is better than the TPC. Furthermore, economic calculations framed the poor dweller in the fringes of the city as the great beneficiary of the new system. However, further research shows that the economies of transport trips did not adjust to engineers' assumptions and estimates, and that in the fringes of the city there are all kinds of discounts awarded to passengers on an ad hoc basis. Transmilenio has none of those. And finally, when confronted with its own inclusive mission in the case of disabled users with wheelchairs, Transmilenio administrators betrayed completely their commitments to social justice, and argued that improved access was a threat to the economic sustainability of the system as a whole.

Through this analysis I have attempted to show how the relationship between social justice and models is not static or straightforward. Engineers and economists use models to support their work. They may be convinced of the social value of the technological system they are creating and how this value should be translated into specific design decisions. But to make the translation they have to use established modeling practices. Not only might models be biased in implicit ways, as shown by Martens, but models are also used and invoked selectively by engineers and economists. In this chapter I have shown how the designers of Transmilenio were at times extremely loyal to the socially just principles of their system and thus resisted the results of established models. But at other times the same designers betrayed their principles and invoked models to support decisions that were technical in nature and prevented an adjustment in favor of improving the social justice value of the system.

I have also flagged three experiences of integration of social and technical aspects in the education of engineers. I presented a case of one course and two educational programs that address social issues as an integral element of the design of objects and systems. These are valuable experiences that can become stepping-stones for those who dream like me with the development of an engineering education program that truly embraces at heart the challenge of world sustainability. If our world is to be truly sustainable we must learn how to design systems that are economically sustainable, environmentally sound and socially just. So far, our engineering programs have focused only in the first aspect. The experiences I have outlined here challenge us to move towards the incorporation of the other two.

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Chapter 11
Exceptional Engineering: Challenges and Opportunities for Socially Just Engineering in Non-governmental Organizations in Colombia

Richard Arias-Hernandez

Abstract Scholarly work usually characterizes engineers as politically and socially conservative individuals; instruments of the expansion of capitalism and neoliberalism. It also portrays them as supporters of both the State and the big corporations that employ them. However, counterexamples have also been documented historically in which engineers have supported social justice and sided in favor of labor and other social movements, sometimes even placing themselves in open confrontation against capital and the State. This chapter relies on ethnographic analysis to document the work of a group of engineers in Colombia who decided to create a space of exception to neoliberalism in the form of a Non-Governmental Engineering Organization (NGEO). These engineers had found that running their own NGEO provided them with some degrees of freedom to pursue social justice goals in their engineering work in ways not usually found in the corporate or neoliberal governmental worlds. However, these opportunities do not come without outstanding challenges, such as funding dependencies from a neoliberal government, which create contradictions that may hinder the engineers' pursue of social justice goals.

Keywords Engineering and social justice • Engineering and neoliberalism • Sociology of technology • Politics of technology • Sociology of engineering

11.1 Introduction

One way of expressing commitments to social justice in engineering work can be found in non-governmental engineering organizations (NGEOs). NGEOs are founded or headed by engineers with the explicit purpose of designing technologies

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to improve the conditions of low-income people. These organizations offer empirical windows to probe into the meanings and daily practices of collectives engaged in putting engineering to work for social justice. In these sites, engineers evolve and sustain social worlds with others who share similar concerns and frustrations about putting engineering to work for social justice. In doing so, engineers put forward their own interpretations of social justice to justify and shape their actions. What are these interpretations of social justice used by engineers to influence their practices and technologies? Are these interpretations consistent, stable, and equally shared? What are the challenges presented to engineers committed to social justice in neoliberal contexts? How do engineers respond to these challenges? Capturing and documenting the action-driven meanings of social justice held by these engineers is a necessary requisite to understand better the dynamics of engineering and social justice.

Ethnographic research conducted in 2007 in one NGEO of systems and computer engineers in Colombia showed that understandings of social justice held by engineers are heterogeneous, unstable, and not equally shared within the organization. Attempting to grasp at once an encompassing scheme of this universe of meanings only produced a motley picture of contradictory and incongruent meanings and actions. However, when limiting these observations to specific situations, and sometimes individuals, it was clearly observed that engineers created consistent pockets of social justice discourse, whose stability and congruency could only be understood when informed by the temporary and pragmatic situation at hand. This chapter explores the ethnographic data to illustrate and support these arguments.

The first part of this chapter describes Somos Más, a NGEO formed by systems and computer engineers that provides information technology to other NGOs and grassroots organizations. The second part focuses on two case studies that highlight the contradictions and challenges faced by Somos Más engineers in implementing their vision of engineering for social justice in a neoliberal context. The final part reviews the main theoretical aspects highlighted by the case studies and elaborates on the implications for non-governmental engineering organizations and engineering education institutions interested in creating spaces of exception to neoliberalism.

11.2 Somos Más

Being dissatisfied with the prospects of working for Colombian corporations and government, in 2001, a group of friends from Los Andes University, all of them system and computer engineers,[1] decided to venture into the mostly uncharted territory of nonprofit, engineering work. Inspired by new millennium, technological imaginaries of a network society (Castells 1996) and discourses of governance

[1]A Colombian system and computer engineer is normally trained in the basic engineering core, computer science, computer systems engineering, software engineering, organizational informatics, and a few elective courses, which may include liberal arts, social science, and humanities content.

networks in neoliberal contexts (UNCGG 1995; Launay 2005; Kurbalija and Gelbstein 2005),[2] the young engineers got together and decided to put their technical knowledge to work for the expansion of a networked nonprofit sector in Colombia. The idea of designing information and communication technologies to network the non-profit sector was strongly manifested in the way they chose to name their start-up: "Somos Más." "Somos Más" translates in English as "we are many more,[3]" and it embodies the idea that together, as a network, the nonprofit organizations are more visible and stronger.

Somos Más engineers' dissatisfaction with the traditional niches of engineering work arose from a perception of conflicting values. Somos Más engineers perceived engineering work in corporations and the Colombian neoliberal government to be misaligned with social responsibility and ideas of distributive justice. Somos Más engineers shared a history of volunteer work, catholic upbringing, participation in grassroots organizations, and a critical posture against neoliberalism and capitalism. They distinguished themselves from other engineers working in corporations and the government in the language they used (i.e. the "third sector[4]" language), their personalities (e.g. empathetic, patient, approachable, and willing to share their knowledge), their values (e.g. distributive justice, non-capitalist interests, etc.), their ideologies and discourses (i.e. progressive and anti-neoliberal), the engineering methodologies they used (e.g. participatory design, action research, etc.), and the kind of technologies they developed (Arias-Hernandez 2008).

In 2007, when the fieldwork for this chapter was conducted, five computer engineers and one social communicator constituted Somos Más staff. The social communicator and one of the engineers were female; the other four engineers were male. By this time, the group of social entrepreneurs had already participated in several projects with other NGOs, all of them promoting the idea of networking Colombian nonprofits. In addition to an online news portal for NGOs (Ramirez 2002), they had also implemented an Internet platform for social networking[5] to connect volunteers (offer) with nonprofits (demand), and they had advanced their own software prototype for an organization-to-organization (O2O) social network for the nonprofit sector. These projects gave Somos Más engineers quick national recognition and visibility, especially after the technological nonprofit won one of the prestigious magazine Dinero's 2004 Ventures Award, in the "social" category (Somos Más 2012).

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[2] Neoliberal policies in Latin America were designed not only to shrink the State and make it "more efficient," but also to shift the balance of power in society from governments and the public sector to private-public "networks." Within neoliberal development circles this kind of institutional reform came eventually to be identified with "good governance" (UNCGG 1995; Launay 2005; Kurbalija and Gelbstein 2005).

[3] According to their founding members, they named their NGEO "Somos Más" because it connotes their interest in networking NGOs and in helping the nonprofit sector to know itself and keep growing.

[4] The nonprofit sector in Colombia is also known as the "Third Sector," in reference to the other two sectors: the for-profit private sector and the public sector (Villar 2001).

[5] http://v2v.somosmas.org/v2v.php, Accessed on: April 12, 2012.

11.3 Socios Por Bogotá

Increasing visibility allowed Somos Más to be approached not only by nonprofits and grassroots organizations, but also by government agencies and private companies. In 2006, Somos Más accepted to work with the City of Bogotá[6] in the project "Socios Por Bogotá" (SPB), which translates as "Partnership for Bogotá." SPB started in 2005 as a voluntary network of public and private (for-profit and nonprofit) organizations created to structure multi-agency projects that could "maximize resources, knowledges and generate more impact in processes of development in Bogotá" (SPB 2006).

SPB also aimed at channeling financial resources from international cooperation agencies, development organizations, and private corporations to a unified "development network" of collaborating agencies. The basic principles of SPB were: (1) Organizations involved in programs and projects for development in Bogotá could join the SPB network voluntarily; (2) Organizations and their projects in SPB would make visible (and quantifiable) a social map of actors and activities involved in city development projects to City Hall and to any other interested actors; (3) SPB organizations would receive training to identify and create strong partnerships in order to make the most out of the network; and (4) Emerging collaborative projects created by "partnerships" among members of SPB were stated as the desired outcome.

Not only the emphasis of SPB on "networking" was organizational, it was also technological. SPB had a technological component called "the social map of Bogotá." The "social map" consisted of a centralized database with information about private actors (i.e. nonprofits and for-profits) implementing development projects in Bogotá. The first version of the database included their identification, location, activities, fields of action, target population, and location of targets. This information was to be available on the Internet and be queried by using an interactive geographic information system, or by sending direct textual queries to the database. City Hall's SPB staff and Somos Más engineers designed jointly this web-based technological system.

Because several of the biggest organizations of the civil society had already an Internet presence and most of the requested information available online, the group of designers decided that "the social map of Bogota" was going to be fed in two ways: manually and automatically. Manual input of information was provided to small and "disconnected" organizations without online presence. Automatic input of information was provided to big players with online presence, via web services. Thus, right from the start, the information system segregated among users, small users with lower budgets having to dedicate more labor, time, and personnel to feed the database than big organizations with already established technological systems. From a social justice perspective, the design of the technological system started

[6] Bogota is the capital city of Colombia. It is also the biggest city in the country with 7.4 million inhabitants in 2005 (DANE 2005).

early to display contradictions among conflicting values. On the one side, Somos Más engineers attempted to imbue their system with values such as trust, voluntary association, collaboration, and synergy among heterogeneous actors in the sake of social development. But, on the other side, pre-existing inequalities among the actors such as segregation by organizational, technological, and economical categories manifested early in the design of the informational system.

During the technological design, deeply enrooted values held by Somos Más engineers also clashed with values held by City Hall's SPB staff. Within the design group, there were some notable disagreements, mostly evident in clashes over different interpretations of the object being designed. The most visible disagreements between Somos Más engineers and the SPB staff were: (1) the role of coercion in the "social map of Bogota," and (2) the increasingly regulatory character of the network.

For Somos Más' engineers, a social network platform involving nonprofit organizations required to be voluntary and to inspire trust. Nonprofit organizations would join once the value of being in the network became clear to them. However, once the project took off and data started to be collected and centralized in the database, the Mayor's Office saw this concentration of data of nonprofits as an opportunity to monitor and regulate nonprofit organizations, whose information up to that point had been normally scattered, distributed, incomplete, unreliable, or too imprecise to be useful for regulatory purposes. This was promptly followed by the enactment of a city resolution (Resolución 072). The resolution commanded city agencies in charge of the inspection, regulation and control of nonprofits in Bogotá, to ask nonprofits in Bogota, using newspapers and other mass media, to update their information and legal status in the new information system provided by "Socios Por Bogotá." Those nonprofits that did not update their information in the new system developed by Somos Más would become the target of multiple disciplinary sanctions, including loosing their legal status. Thus, with the enactment of the city resolution the initial characteristic of the socio-technical network that allowed nonprofits to join the network voluntarily was lost and shifted towards compulsory use. The value of trust was also lost and replaced by the suspicion that the city government would use the data provided by nonprofits to regulate them.

The inclusion of governmental coercive measures to obligate nonprofits to input their data into the information system caused a major conflict within Somos Más engineers. They saw the system diverging from its original principles of trust and voluntary participation and they feared that their work was going to be used to regulate nonprofits in Bogota:

> We [Somos Más] never liked that approach of threatening nonprofits with the cancellation of their legal status if they did not input or update their data in our system. With regards to that aspect, we were initially against it. What we wanted was to generate spaces of trust to motivate social networking, start with just a few who truly wanted to use the system and keep growing from there. (Interview with Nicolas Martin, engineer, Somos Más)

The design of the database for the "social map" was also modified by the Mayor's Office. The Bogota Chamber of Commerce suggested to the Mayor to include additional fields to the database to capture financial statements from the nonprofits to be able to audit a larger number of these organizations that traditionally did not send their financial reports to the city. Thus, Somos Más engineers were asked by the SPB staff to include such fields to the database. This was a difficult situation for the engineers because clearly, the purpose of these financial fields had nothing to do with the initial networking goals and the basic principles of the SPB project. However, at that point Somos Más engineers were already bound by a contract with the Mayor's Office to introduce all of these changes no matter how reluctant the engineers were.

A second modification in the design that manifested the introduction of coercion as a shaper of the system was the introduction of alarms for outdated information. The information system incorporated a system of alarms that tracked how current the information entered by the nonprofits was. The idea behind this system of alarms was to impose a technological imperative (Winner 1977) on nonprofits. If a nonprofit did not actualize their information, at least once every 3 months, the system would generate a series of alarms (e-mails and regular mails) that the legal representative of the nonprofit would receive. These alarms would remind the nonprofit to update its information. If no action from the nonprofit were taken, 6 months after the last update of information, the information system would automatically cancel the electronic record of the organization and inform City Hall and the Chamber of Commerce to proceed with the formal cancellation of the nonprofit's legal status.

The final version of the information system was the result of conflicting and contradictory purposes and values. On the one hand, the web portal of SPB offered a space for nonprofits to interact voluntarily with each other in an online space for social networking, and to create sub-networks and partnerships around projects for development. On the other hand, the system was designed to allow City agencies to monitor and regulate the activities of nonprofits in Bogotá, making the "networking" value less attractive for organizations that benefited more from not being regulated by the city's government. In other words, for most of the nonprofits the SPB information system had costs (i.e. being regulated by the City government) that outweighed the benefits of "networking."

From an anthropological and sociological perspective, it was interesting to observe the engineers' response to the circumstances that contradicted their original values of voluntary association and organic collaboration imbued in their original design. As previously mentioned they had to abide by the contract they had signed with the City to introduce coercive and regulatory modifications, even though they were ideologically opposed. The engineers' first response came in the form of a reframing of "coercion" and "regulation" as a coping mechanism to resolve the cognitive dissonance produced by their own implementation of these modifications. Somos Más engineers gradually eased their initial resistance to coercion and regulation by creating a discourse in which "coercion" and "regulation" were redefined as positive "values" that could benefit small nonprofits, in particular, and the third sector, in general:

> In any case, the law orders that any organization should be registered in the Chamber of Commerce and in the City Hall … this is a necessary step for any organization to do its job. (Interview with Diego Ramirez, engineer, Somos Más)

> It is necessary to know from a legal aspect which are the nonprofits that are really doing their job … *some of them will even benefit from having their legal status removed*, in the sense that the process of liquidating an organization in Bogotá could cost two or three million pesos [USD$1,500] … So, if some of these organizations are already informally inactive but have not had the money to remove their legal status, by canceling their legal status for free we are doing them a favor … now, sanctions will go especially to those organizations that camouflage under the label of nonprofits to run illegal businesses like prostitution or to run a business for profit and not to pay taxes for it. In this point we agreed on this kind of depuration of nonprofits and NGOs in Bogotá. (Interview with Nicolas Martin, engineer, Somos Más)

The engineers gradually constructed a discourse in which the use of coercion and regulation was presented as beneficial for NGOs and other nonprofits, by identifying and removing the bad apples that were taking advantage of the nonprofit sector for illegal purposes (e.g. prostitution businesses) and by "*doing a favor*" to those NGOs that did not have the money to liquidate their organization. This new discourse helped them solve the initial cognitive dissonance introduced by the conflicting values embodied in the design. It also allowed engineers to comply with their contract with the City and, up to certain point, to preserve their intentions of improving the conditions of nonprofits.

The engineers' second response was technological and it opened a back door for non-profits to take advantage of the benefits of networking while circumventing the City's coercion and regulation. One of the engineers included in the final design of the information system a subversive technological option to allow anyone with technical skills to "hack" the search center and have access to the database without being registered as an authorized user of the system. This option consisted in an open connector to which anyone technically capable of developing a web service could connect freely. However, it had the obvious inconvenience that this option was restricted only to people with expertise in computer systems, which are not common in the third sector.

The departure from the initial intentions and the modifications to the SPB project and its information system had a bigger impact, though. In the end, the city resolution backfired. Several of the nonprofits that were initially attracted by the idea of voluntary association dropped out of the SPB project when the coercive and regulatory character of SPB became evident. More conclusively, the nonprofits' response to the open call submitted by The City using mass media was extremely disappointing. From an estimated number of 40,000 nonprofits in Bogota in 2006, only 12,000 (30 %) responded to the open call ordered by the city resolution. These 12,000 nonprofits fed the information system developed by Somos Más with the requested data: identification, activities, target populations, location of their targets, and financial information. However, the rest of nonprofits (70 %) remained clandestine defeating both former intentions of voluntary "networking" for development and the latter intentions of regulation. The change of city government in Bogotá in January 2008 brought this project to a halt. Currently the system is not operational and the initial aspirations to create a network of NGOs and nonprofits in Bogotá for development (and regulation!) were not fulfilled.

11.3.1 Interpretations of Social Justice

A pattern of the co-evolution between an engineering project and its related interpretations of social justice can be observed in the "Socios Por Bogota" case study. This pattern is structured around three main temporary stages characterized by the stability or instability of social justice meanings.

The first stage corresponds to "time zero" (t0), in which both representatives of City Hall (SPB staff) and Somos Más engineers shared a vision of the project that assumed an initial interpretation of social justice as distributive justice. In this vision, the SPB project was assumed to distribute equally the range of opportunities and benefits available for development projects in the City among private actors (nonprofits and for-profits) regardless of how small or big these organizations were (organizationally, technologically, and financially). Engineers in this phase clearly endorsed distributive justice values and incorporated them in the initial stages of design. We can also identify this initial phase of stability by the high level of agreement on the substantive values endorsed by the project among the parties involved. Let's call this phase of stability: "initial stable interpretations."

A second stage corresponds to "time one" (t1). In this stage, contradictions to the initially endorsed values of social justice started to manifest. Some of these contradictions were subtle and not perceived as such by engineers, such as the dual mechanism suggested by the engineers to feed the "social map" database that segregated among small and big organizations. On the other hand, some of these contradictions, especially those coming from other actors, were explicit and clearly visible to engineers. The most evident example of these visible contradictions was the imposition of coercion and regulation by City Hall to the SPB project that directly conflicted with values of trust, voluntary association, and organic collaboration. Using the framework of distributive justice, we can note that the initial stable interpretation of equal distribution of *opportunities and benefits* was altered by City Hall to include also an equal distribution of *obligations and burdens*, not initially contemplated by Somos Más engineers, in the design of the SPB technological network. Thus, we can identify this secondary phase as being characterized by conflicting values and conflicting interpretations of social justice endorsed by the participating actors. Let's call this phase of conflict: "contradictory interpretations."

The third and final stage corresponds to "time two" (t2). In this stage, participants deployed strategies to manage the contradictions generated in "time one," while trying to maintain some degree of consistency and commitment to the initial values endorsed in "time zero." Two strategies were mentioned in the SPB case: (1) recovery of stability and consistency by the creation and endorsing of new interpretations that could resolve the contradictions between conflicting values; and (2) the design of subversive technologies. The first strategy used by Somos Más engineers allowed them to underplay the distribution of burdens and obligations and to emphasize a "new" re-distribution of benefits for nonprofits provided by the rephrasing of some of the burdens, such as the idea that losing the legal status could actually be

Table 11.1 Co-evolution of an engineering project and interpretations of social justice

Time	Actor	Project interpretation	Social justice interpretation	Stage
t0	Somos Más Engineers	Network of trust and collaboration for development projects	*Initial* version of Distributive Justice focused on *benefits/opportunities*	Initial stable interpretations
	City Government	Network of trust and collaboration for development projects	*Initial* version of Distributive Justice focused on *benefits/opportunities*	
t1	Somos Más Engineers	Network of trust and collaboration for development projects	*Initial* version of Distributive Justice focused on *benefits/opportunities*	Contradictory interpretations
	City Government	Network of control, regulation and collaboration for development projects	*New* version of Distributive Justice focused on *burdens/obligations*	
t2	Somos Más Engineers	Network of control, regulation and collaboration for development projects	*New* version of Distributive Justice focused on *benefits/opportunities*	Complementary re-interpretations
	City Government	Network of control, regulation and collaboration for development projects	*New* version of Distributive Justice focused on *burdens/obligations*	

beneficial for some nonprofits. The second strategy used by Somos Más engineers allowed them to maintain the initial interpretation of distributive justice focused only on benefits and opportunities, but required the use of a subversive technology. Both strategies allowed engineers to recover stability of interpretations and resolve the contradictions they confronted during "time one." Let's call this new phase of stability: "complementary re-interpretations." Table 11.1 summarizes the main points highlighted by the observed dynamics of the co-evolution of this engineering project and its interpretations of social justice.

The "Socios Por Bogota" case portrays the non-governmental engineering organization as an integrated, homogenous social unit; a social whole with a share understanding of the values to be imbued in their technological designs. When conflicts between contradictory values arise, these conflicts occur not within the organization but between the shielded NGEO and other project stakeholders. In other words, in the case of SPB, for Somos Más engineers the value conflict separated "them" from "others" (i.e. the City government) reinforcing the idea of being an exception to the neoliberal establishment represented by the “others.” However, this condition of internal agreement and cohesion around values and principles seemed to have been more a reaction to external challenges than an intrinsic property of the social group of engineers. During the ethnography, the observation of the “back-end” (Goffman 1961) of the NGEO, demonstrated that internally, there was no such a thing as a unified and shared agreement among all of the engineers who constituted Somos Más. In terms of values, there were rather “levels of agreement” and “levels of disagreement” in regards to specific principles and values. The second case study “Microsoft and the O2O project” will highlight this point.

11.4 Microsoft and the O2O Project

Somos Más engineers endorse the ideology of free software. The software they use, and the software they produce for other NGOs is free software. They see proprietary software as an object proper of informational capitalism (Castells 1996). They reject it and they do not identify with it as technology developers. Relying on free software also allows Somos Más engineers to offer a cheaper product for NGOs that do not have big budgets for ICT infrastructure, something that aligns with ideas of distribute justice: universal access to technological products regardless of budget size in the nonprofit sector. Most of the engineers from Somos Más were members from the free software community before joining Somos Más. For these engineers, joining the social world of non-governmental organizations was a natural consequence of their previous alignment with non-capitalist ideas about information and information technologies (Schiller 1996; Lessig 2006; Benkler 2006):

> I began my professional development thanks to Linux and the free software. That is why I have a strong proximity to the idea of sharing with others. The idea of sharing the products of my work with others … I have my ideas, I ground them in a product, and when they are out there, they become a public good, something to be enjoyed by whoever who needs it … this is the idea behind public licenses and free software, and this is also the same idea behind my work in an NGO. A private firm acts for its own benefit. NGOs, and other organizations in the third sector, act for the benefit of others. So, in this spirit, developing software in the third sector cannot be done thinking that what I am doing is for me, that is contradictory. When you work in a NGO, you cannot believe that what you are doing is for your own benefit, because everything you do, you do it for the benefit of others. (Interview with Diego Ramirez, engineer, Somos Más)

This commitment to the ideals of free software, however, was stronger in some Somos Más engineers than in others. In other words, among the engineers there were different *degrees of commitment* to the ideals and values found in the free software ideology; and this difference in degree mattered. Even though most of the time it did not have a significant impact in the daily matters of the organization, this difference among members was also the cause of internal conflicts and different individual predispositions to respond to specific situations, specially when the commitments to free software were threatened by capitalist values. One of these specific situations was observed during the fieldwork at Somos Más, when Microsoft, the commercial giant of proprietary software, approached the NGEO to propose a temporary alliance. The possibility of this alliance arose from the intersection between the social world of the NGOs and the social world of the private sector around the issue of "Corporate Social Responsibility."

Microsoft in Colombia runs a number of social programs and projects under the umbrella of corporate social responsibility (CSR). In 2007, the director of Microsoft's CSR program, contacted Jefferson Ramirez, director of Somos Más, to offer him the possibility of funding the expansion of Somos Más' software prototype for the social networking of NGOs, called O2O (organization-to-organization):

> When the director of social responsibility in Microsoft told us that she was going to give us money to make the O2O, we were tempted to accept the money. We thought it twice, though. "Well … they are going to give us the money, but no …," in the end you say "no." Because the source of that money is not compatible with our internal policies, … so, "no." We are very strict on that, we stick to our principles. Someone once said that a mature software firm was one, which could be measured by how often it says "no." So, I think we have matured in that aspect. It does not open our eyes wide that someone is going to finance us, but other things. So we are proud to say "Microsoft offered us money, and we said no." That is something that comes from our principles. It was so important to me than I thought to myself: "if Microsoft finances me, I will not work with that money, because that does not interest me." I think we have gained a tacit coherence between what we believe in and what we do here in Somos Más because we do not have that written. (Interview with Diego Ramirez, engineer, Somos Más)

This decision of rejecting the proposal of Microsoft to finance O2O was a collective, but not unanimous, decision. As a matter of fact, Jefferson Ramirez, director of Somos Más, was one of the engineers without a strong commitment to free software, and the most outspoken voice in defending the potential alliance with Microsoft. From his perspective, the alliance with Microsoft was a good opportunity to finance Somos Más' O2O project. He also carried with him the bias of having worked with Microsoft previously in other projects of his own. This made it difficult for him to say "no" to Microsoft's offer.

The different internal conflicting perspectives about the potential alliance with Microsoft had to be resolved in an assembly of all of the Somos Más members. In that assembly, every Somos Más member presented her/his own view on the matter and a general vote was called for to settle this issue. In the end, majority decided to reject Microsoft's offer and an engineer other than the director was chosen to present the decision to Microsoft:

> We have been radical about free software … I was the one chosen to face the Microsoft people to let them know that we were not going to accept their offer. I had to do it alone, by myself, because here in Somos Más, we have different opinions and positions with respect to Microsoft, so we could not give a unified answer to those people. Jefferson has his vision, Diego and I have a different vision, and more often it is Jefferson who makes the talking, but this time I had to do it because he was in favor of accepting Microsoft offer. (Interview with Nicolas Martin, engineer, Somos Más)

For Jefferson Ramirez, the strong and inflexible commitment to free software by some of the engineers in Somos Más was perceived by him as non-beneficial. For Ramirez, the organization needed to deal with financial struggles and the realities of scarce financing commonly found in nonprofits, let alone technological nonprofits. He thought that Somos Más needed to develop alliances with the public and private sectors, nationally and internationally, in order to guarantee its organizational and financial sustainability.

> I agree with the principles of free software up to the point where these principles turn into barriers to creating relationships with someone who does not share them … because we also need to survive, and to survive we need to attract income and funding. Not everything is passion; we also need to pay wages! (Interview with Jefferson Ramirez, engineer, Director of Somos Más)

Although Somos Más rejected Microsoft's offer to finance their O2O project, Ramirez still maintained an independent and individual relationship with Microsoft as a consultant. This shows that the difference in *degrees of commitment* to the non-capitalist values endorsed by Somos Más engineers mattered. For some of the engineers, with a high level of commitment to the free software world, establishing an alliance with Microsoft was a contradiction in principles and values that needed to be stopped. For Ramirez, with a low level of commitment to the free software world, the nurturing of a relationship with Microsoft was necessary and good for the organization. Ramirez's role as an independent consultant for Microsoft, rather than as representative of Somos Más, was a consequence of deviating from the internally established normativity and ideology endorsed by the majority of Somos Más members. It also showed that internal coherence and consistency around values and principles was not permanent and it was continually challenged by the social interactions of Somos Más members with other social worlds.

Even though, this event demonstrated the existence of internal disagreements, it also allowed the NGEO to clarify their ideological positions, understandings, and meanings to other organizations, such as Microsoft, having the effect of strengthening the in-group/out-group distinction (Graham 1906) with respect to corporations endorsing informational capitalism. As a result, Somos Más' portrayal as an "exception" to capitalist, neoliberalist engineering was also reinforced.

11.5 Discussion

Engineers are normally characterized as politically and socially conservative individuals, portrayed as instruments of the reproduction of capitalism and neoliberalism (Noble 1977, 1984; Riley 2008). A few scattered counterexamples have documented moments of upheaval in which engineers have supported social justice (Chap. 2 by Nieusma in this volume) and sided in favor of labor and other social movements, sometimes even placing themselves in open confrontation against capital and the State (Layton 1986). However, this seems to be the exception rather than the norm, at least in contemporary liberal democracies and neoliberal states.

Anthropologist Aihwa Ong (2006), in her study of neoliberalism as governmentality, finds that engineers occupy a central place in this governmentality. In Asian neoliberal contexts, engineers are some of the subjects who are most frequently targeted, and who have asymmetrically benefited the most by policy-making, due to the privileged place that science and technology occupies in neoliberal approaches to economic development.[7] Neoliberal policies, for example, promote social programs and research that aim at increasing the number of students enrolling in engineering programs. Grants are also available for engineering start-ups and engineering research and development in the expectation that technological innovations will be created to foster national economies. Technological parks and clustering of engineering start-ups are encouraged and sponsored by neoliberal governments in the hope of developing the Asian equivalent of "Silicon Valley." Engineers, like other skilled professionals, are granted protections and benefits by neoliberal policies that are not offered to individuals who join the ranks of "redundant labor" or "unskilled labor" (e.g. maids, janitors, waitresses, public transportation drivers, etc.), since these neoliberal calculations include and exclude individuals on the basis of their perceived value to national economies (Ong 2006). Thus, having a high-perceived value to neoliberal economies, engineers are treated as exceptional citizen-subjects that enjoy extraordinary political benefits and economic gain. Using Ong's perspective, we can understand engineers as being part of the skilled labor force that constitutes an "exception *for* neoliberalism." In other words, neoliberalism justifies "exceptions" for the unequal treatment of some citizens-subjects, privileging some social groups, such as engineers, over others. Engineers as exceptions *for* neoliberalism are enrolled in a growth loop: neoliberalism grants special exceptions to engineers in the hope that engineers will strengthen neoliberalism. This characterization however, does not seem to fit the kind of engineer and engineering being described by the fieldwork data on the Colombian, non-governmental engineering organization, Somos Más.

Relying on the same theoretical framework, it seems more appropriate to depart from Ong's original characterization of *all* engineers as "exceptions *for* neoliberalism" and to develop a symmetrical understanding of, at least *some*, engineers as "exceptions *to* neoliberalism." This is the kind of engineer and engineering that attempts to resist market calculations, something that I refer to as "exceptional engineers" and "exceptional engineering," extending from the original concept proposed by Ong. One consequence of this confrontational resistance to neoliberal calculations is for exceptional engineers to enroll the ranks of those excluded from the traditional benefits of neoliberalist calculations. This departure of engineers from being an "exception *for* neoliberalism" to become an "exception *to* neoliberalism" is manifested by identity ruptures, such as those observed in Somos Más, that create a engineering identity that is different than the mainstream engineering identity.[8]

[7]This argument mirrors previous Marxist discussions about the privileged place of engineers in class struggles, in which they occupy an intermediary position between capital and labor but in which they ultimately side with capitalist interests to enjoy the benefits of future careers in management (Noble 1977, 1984).

[8]A more elaborated discussion and evidence of these identity ruptures can be found in Arias-Hernandez (2008).

This explains why these engineers see themselves, and are seen by others, as different than traditional engineers. Another consequence is for engineers to depart from spheres controlled by capital or by the neoliberal state. In the case of Somos Más engineers, the only option that seemed plausible in the Colombia context was to move to the nonprofit sector and to create a Non-Governmental Engineering Organization (NGEO). Departing from capitalist spheres also constitutes a demarcation on the kind of engineering work that is considered "appropriate" or "inappropriate," as illustrated by the Microsoft case study. Departing from neoliberal govermentalities also constitutes a demarcation on the kind of values and interpretations of social justice that can be endorsed or not, as illustrated by the case of "Socios Por Bogota."

However, as laudable as exceptional engineering can be in neoliberal contexts from a social justice perspective, being excluded from the traditional capitalist normativity and consequential social benefits is a constant challenge. For example, social institutions in neoliberal contexts, such as university education, discourage the construction of this kind of engineers and engineering. Universities and engineering schools develop curricula to construct engineers for the private sector and the "corporate" public sector, but not for the nonprofit sector or for an alternative vision of the public sector. Since the nonprofit sector follows a different logic, engineering schools are normally at odds with a kind of engineering oriented to this sector. Somos Más engineers have experienced this first-hand. During the interviews, it was made evident that the kind of engineering identity that they had developed has not been the direct outcome of their engineering education. On the contrary, it was the outcome of a struggle against the engineering educational establishment and an ongoing inconformity against its normalized neoliberal engineering identity. The neoliberal engineering identity sold to Somos Más engineers conflicted with their previous life experiences working as volunteers with poor communities. Somos Más engineers responded by appropriating their university education to fit their interests and by creating their own space of practices: their own NGEO. For example, they took their elective courses (e.g. social entrepreneurship, political science, etc.) in schools other than engineering and they found mentors in the management school that nurtured their desire to create their nonprofit engineering start-up:

> In many ways, my work here in Somos Más opened a window that I did not think was going to exist for me. When I was at the university I did not want to be that systems and computer engineer working in a bank, or in an office, on the development of a big information system. (Interview with Nicolas Martin, engineer, Somos Más)

Another challenge that comes not from educational institutions but from economic institutions is that to be able to survive, NGEOs need not only to be ideologically sustainable but also financially sustainable. Although some grants from international cooperation agencies are available for these NGEOs, and some demand for technical work comes from the nonprofit sector, the financial constraints have taken them to work for neoliberal governments and for for-profit corporations. These "encounters" have proven to be challenging for NGEOs, such as Somos Más, because they test the demarcations that distinguish exceptional engineering from the more traditional and mainstream conceptions of engineering. Moreover, the interpretations of engineers of a kind of engineering oriented towards social justice are constantly challenged by dominant capitalist and neoliberal values endorsed by corporations and governments. As we have seen in the case studies documented in this chapter, preserving these values places stringent demands on exceptional engineers to continuously reaffirm their values and ideologies in front of unavoidable contradictory values and ideologies.

Event though challenging, exceptional engineering also offers attractive opportunities for engineers and society. For engineers, it offers an alternative professional path to those offered by traditional niches of engineering work in corporations or in neoliberal governments. It also relies on a strong entrepreneurial spirit that resonates with stronger ideas of engineering professionalism, pervasive in the nineteenth century but almost gone by the end of the twentieth century (Layton 1986), such as: autonomy and higher independence from businesses and governments, anti-establishment political ideology, and strong commitments to social responsibility and social justice. Finally, for society, it provides a different kind of professional, a different kind of technical work, and different technical products (Arias-Hernandez 2008). Technical work and technologies that are imbued with social values that do not privilege private property, accumulation of capital, power of elites, regulation, or control, but that rather focus on expanding public goods, reducing poverty, distributing benefits in society and creating a more just society.

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Chapter 12
A Framework for Social Justice in Renewable Energy Engineering

Nicholas Sakellariou

Abstract Engineering practitioners and critics of technology alike frequently claim that core values informing the structure and operation of the engineering profession in the U.S., such as mathematical problem-solving and analytic reasoning, are in conflict with values of social justice. However, there is hardly any documented evidence to measure the presence and practice of social justice in Renewable Energy Engineering (REE), a burgeoning field, whose development is essential to building a sustainable future. This chapter presents information regarding the identification of key engineering skills presently required in the U.S. REE context, drawing on 30 open-ended, semi structured, interviews conducted with educators and professionals who are involved with solar or wind energy engineering. This chapter aims to explore questions of why, how, by whom, and for whom assumptions about the attributes of solar and wind energy engineers are built into the engineering curriculum. Specifically, it invites reflection on the design of teaching strategies and technical methodologies used to integrate these attributes within engineering education and practice. Having outlined the social justice challenges of REE, I argue for the importance of a procedural justice framework for REE projects.

Keywords Renewable energy and social justice • Renewable energy engineering education/curricula • Community involvement/ownership and renewable energy

12.1 Introduction

The current global expansion of renewable technologies reflects the desire of governments, localities and expert constituencies to fight climate change and move

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towards a post-carbon energy system. For example, commercial wind power—with 43,461 MW total installed wind capacity in North America (AWEA 2011)—has benefited from federal and state policies to emerge as a leading technology in the U.S. and worldwide. Similarly, due in large part to federal policy, the U.S. industry in solar photovoltaics (PV) is projected to grow from 5 % of the world PV market in 2011 to 12 % in 2015 (Solarbuzz 2011). Reduced manufacturing costs in China give policy-makers reasons to worry about a "clean-tech trade war." By 2013, mega solar farms like the *Blythe Solar Power Project* will be able to compete on scale with coal and nuclear power plants.[1] The political and economic status of renewable technologies provides incentives for corporate colossi like General Electric and Google to invest heavily in renewable energy (RE) infrastructure. Put plainly, Renewable Energy Engineering (REE) is becoming big business.

At the same time, RE has the potential to create jobs, redistribute the functions and powers of energy systems, and offer communities—social groups possibly affected by an RE project—independence and economic support.[2] In this chapter I argue that since the dominant energy system increasingly reflects society's dependency on the decisions of technical experts, engineers need to develop humane, socially-enriching and creative responses to empower communities in their decision-making. Over the past 40 years, communities in the U.S. have experimented with wind and solar technologies to "break through the political, economic, social, and psychological forces that constrain and oppress [them]" (Boyle and Harper 1976). On the one hand, RE—particularly small-scale projects (Schumacher 1974; Lovins 1977)—*can* solidify community life, redistribute capital and opportunities, and facilitate political self-determination (Winner 1986; Harding 1995; Gordon 2008). On the other hand, studies indicate that most outcomes from RE development have been strictly monetary in nature, while some individuals view projects as a threat to their health and quality of life (Walter and Gutscher 2010).

The potential compatibility of solar/wind power and decentralization suggests plausible, yet unexplored, connections between renewable technologies and social justice (SJ).[3] In the context of this volume, I define SJ as the ongoing struggle of disadvantaged communities to establish equal access to basic services (including energy and a healthy environment) and to overcome any form of social and/or

[1] The term "farm" communicates a sense of idyllic, green and pastoral setting—the exact opposite of the industrial scenery connoted by the term "plant" (e.g. solar or wind plant). In this chapter I have chosen to use the term "project" to describe both solar and wind facilities.

[2] Walker et al. (2010) note that "…narratives [of energy policy in the United Kingdom] are clearly predicated on the basis that 'communities' can and do exist in an unproblematic form and within many of the positive qualities with which they are readily associated." Such considerations, however, are in fact problematic: "[w]hilst appearing inclusive, community can also be deeply exclusionary, marginalizing those who are seen as not fitting." Also, what in each case counts as "affected community" may be contingent on the very type of RE technology at stake. I am thinking particularly about off-shore wind projects. Does "community," in that case, simply mean "coastal community," or must the term be broadened to include the mainland, too?

[3] Otherwise, when generally directing attention to the term/idea, the convention of italicizing *social justice* is used, rather than its referent.

political oppression. Reducing carbon emissions will not *necessarily* make renewable technologies socially just. In this chapter, I offer a preliminary mapping of the developing field of REE in the United States from the perspective of *social justice*. For analytic purposes, I build on the distinction (Gewirtz 1998) between distributive and procedural justice. The former relates to the distribution of an RE project's impacts, the latter to fairness in RE project dispute resolution.

The basic structure of my argument is as follows: REE raises many SJ questions. This may affect how RE projects develop in the future, because there are currently few incentives to work with communities in designing wind/solar energy infrastructures. My proposed solution is to develop a self-reported rating inventory to integrate SJ into REE practices.

However promising the emancipatory potential of RE, there is no energy panacea. All energy technologies involve environmental costs, lay and expert opposition, and risks to public health. Wind technologies, for instance, have environmental and health impacts such as land and materials use, biodiversity, wind blades' recycling and others. Therefore, a number of large-scale wind projects, like Cape Wind, have gone through costly assessments, have been rejected by local officials, or have been opposed by communities. Correspondingly, public concerns are being expressed with regard to large solar facilities—for example, in L.A. County's Western Antelope Valley—where project development is perceived as a potential threat to agricultural land, local wildlife and community cultural values.[4]

In this chapter, I hypothesize that the assumed support for renewables by "the general public" has legitimized the choice of RE engineers to abstain from engaging with local opposition to technologies.[5] Some engineers believe that the difference between the perception of the "public" being supportive of RE and individuals or local groups resisting projects is explained by the supposition that people endorse RE only as long as facilities are not located "in their backyard." Investing the idea of

[4]A 2009 press release by the British Wind Energy Association (BWEA) was lamenting over the finding that "local council approvals of wind farm applications have fallen to a shocking new low of just 25 % (BWEA 2009)." In addition, according to a recent news report (Derbyshire 2011), data obtained by the British law firm McGrigors shows a growing percentage of wind farms being turned down by planners in the last 5 years (29 % in 2005, 33 % in 2009 and 48 % in 2010). The fact that the increase in the percentage of opposition is partly due to the increase in the number of project applications does not negate that project opposition suggests a significant concern in RE development internationally. I could not find a good source of aggregate data showing combined (solar and wind) opposition against RE projects in the U.S. The best source for community resistance to wind energy in North America is Phadke's (2011) work, which uses GIS technology to plot the wind oppositional movement in the U.S. in the last 5 years. Finally, the reader must note that many proposed projects do not get built, and may not go forward for financial or other reasons.

[5]For instance, in February 2012, San Francisco based non-profit organization "The Vote Solar Initiative" released a public opinion poll on what communities in the desert counties of Southern California think about solar–project development (http://votesolar.org/2012/02/polls-california-desert-communities-support-solar-development-care-about-climate-change/). Vote Solar says respondents "overwhelmingly" support solar project development in the desert (75 % voted in support of solar projects). However, the study does not account for the proximity of respondents to proposed projects (Vote Solar 2012).

so-called "Not in My Backyard" (NIMBY) with connotations of "emotional" or "irrational" rejection, critics assert that NIMBY-ism is "the first insult that big developers throw at their opponents…[arguing further that NIMBYs are] selfish, short-sighted *enemies of progress*, prepared to put their narrow interests above those of a wider society" (Kingsnorth 2004, emphasis added).[6] Social scientists, however, theorize communities' resistance in terms of what they call a "social gap"—a disparity between high levels of public support for RE and high levels of local opposition—arguing that the idea of NIMBY-ism oversimplifies opposition to RE (Bell et al. 2005). In this chapter I side with scholars who have remarked that the language of NIMBY-ism is unlikely to lead to a resolution of the complex socio-technical dilemmas that pertain to RE opposition (Burningham 2000; Wolsink 2000, 2006).

Parallel to the mounting opposition to wind and solar project-development (Phadke 2011; Wolfson 2011) runs the movement of creating, communicating and distributing RE expertise. For a variety of reasons—including the move by the American energy engineering profession to embrace basic RE topics, such as energy storage and energy transmission, in engineering curricula—we are currently witnessing a proliferation in RE degrees, certificates and related programs around the country (see Appendix A). One of the driving forces behind the expansion of RE-related educational initiatives is the desire to generate more "green jobs." In the US, for example, a 1-year extension of the 1603 Treasury Program is predicted to add another 37,000 jobs in solar, to the 100,000 that already exist (EuPD 2011).

This chapter is divided into four sections. Section 12.2 illustrates some of the social justice implications of REE. Sections 12.3 and 12.4 summarize the results of 30 interviews conducted with RE educators, practitioners, and professionals; Sect. 12.5 offers a historical explanation for why social justice remains a contested issue in engineering. The interviews for this chapter were guided by the following research problem: To what extent, if at all, do concerns of social justice influence the question of "who counts as an RE engineer"? Finally, Sect. 12.6 presents a basic overview of the literature on local opposition to RE projects, arguing that scholarly analyses have thus far largely overlooked the role of the "engineer" in RE. The suggested remedy for this omission is a procedural justice framework that construes local opposition as the interaction between "Community" and "Engineering".

12.2 Some Social Justice Implications of REE

Designing RE systems has crucial implications for SJ, a reality that the engineering profession has yet to address fully. Questions of SJ as they pertain to the solar energy sector can be traced back to the 1980s (Pellow and Park 2002), when activists began

[6] Wolsink (1994) notes that in some cases RE proponents have likened NIMBY with a social disease (e.g. "NIMBY syndrome").

challenging the use of toxic chemicals by Silicon Valley electronics manufacturers (PV technology depends on the same toxic manufacturing techniques as electronics). More recently, a “new wave” of SJ activism has been forming around the siting and design considerations of solar and wind projects. SJ implications of REE are associated with both the design choices that manufacturers make, and with the siting choices that companies make, whether these be factories or actual projects. Engineers are playing a central role in shaping SJ outcomes in RE systems.

One instance where SJ came into play concerns PV technology: The life cycle of PV technologies involves “blind spots” which may engender social and environmental justice problems. For example, the polysilicon manufacturing processes—key to producing the majority of PV systems, located mostly in Chinese industrial facilities—have been linked to the dumping of silicon tetrachloride on agricultural lands (Cha 2008; Nath 2010). This circumstance raises serious ethical and environmental considerations with regard to the sustainability of PV’s life-cycle, for silicon tetrachloride is a toxin causing skin burns, lung cancer and crop infertility.

In addition, the more economic and faster-to-manufacture (thus increasingly more popular) thin-film PV technologies depend on toxic materials like cadmium and selenium. In thin-film PV, the fact that tellurium (a component found in the common thin-film alloy cadmium telluride) is a very rare metal, gives rise to concerns about end-of-life PV modules entering the global e-waste trade: PV waste involves a very toxic material (cadmium) attached to a rare-earth material (telluride). Using toxic and rare earth materials in PV manufacturing is an example of the *social justice* implications of REE involving several facets: mining and processing impacts on humans and the environment, the unreliability of the supplies, and the toxicity associated with the material. In short, REE “green jobs” could be a double-edged sword as they may potentially replicate the injustices associated with the semiconductor industry. Such jobs could bring groundwater contamination and occupational health burdens to the very communities whose economies they are meant to revitalize (Mulvaney forthcoming).

Another example of *social justice* considerations in REE is the siting of wind and solar projects. Although aesthetics have been central to the opposition discourse against wind energy projects (e.g. Wolsink 2000), the industry has mostly engaged with issues related to health, wildlife, and property values. For example, an independent advisory panel commissioned by the leading American and Canadian wind associations concluded recently that “there is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects” (American Wind Energy Association and Canadian Wind Energy Association 2009). Yet health practitioners have built on extensive fieldwork with people around the globe who claim that “their lives have been ruined” by RE, and who further warn that “the negative psychological effects of *disempowerment* interacting with the adverse health effects attributed to IWTs [industrial wind turbines] has intensified the negative synergy of *justice lost*” (Krogh 2011, emphasis added). Creating new channels of communication between engineers and communities is key, for as long as “the exact cause of IWT-induced adverse health effects is not fully understood," (Krogh 2011) failure to communicate risk and uncertainty prompt injustice.

Wind and solar projects can be perceived as disturbing cultural and archaeological landscapes because landscape aesthetics are interlinked with values, identities and imageries. Phadke (2011) notes that "[w]ind energy opposition politics are essentially battles over rural space; over who controls the productive and consumptive qualities of rural landscapes." Her reference to cultural historian Leo Marx's idea of the "middle landscape" as dialectics of space and technology is pertinent to how RE proponents and opponents view and negotiate their dynamic relationship with a project's spatial and cultural surroundings. Contrary to aesthetics, which is highly subjective, property values represent a quantifiable version of a "sense of place" as it relates to financial (in)security. Although some studies have shown that, for instance, houses with PV installations in California sell faster and at higher prices (Hoen et al. 2011), until now very limited data is available relating property values (wind) or residential values (solar) with RE project development. Furthermore, even something relatively straightforward, like house values, becomes controversial: what methodology is appropriate to measure whether there has been an impact or not? Similarly, health studies of RE projects' implications that are based on surveys may be challenged as "biased."

The interaction between wildlife issues and landscape and cultural concerns also attests to the *social justice* implications of REE. For instance, the Ivanpah solar project in California, U.S., although currently under construction, faces lawsuits brought by the non-profit organization Western Watersheds over the facility's impact on desert tortoises, and by the cultural group La Cuna de Aztlan regarding assumed violations of Native American consultation rights. Bird, bat and other wildlife mortality due to RE technology development has been reported since the 1970s, and while the industry has commissioned studies and led initiatives to investigate the issue, more research is essential.

The nexus between RE and SJ is highlighted by interviewees in terms of community empowerment: by gaining a seat at the table for making important project decisions, having access to resources and information, and creating mechanisms for building and sustaining trust between technical experts and communities. One interviewee with experience in wind industry issues mentioned:

> …[the] opportunity for the interaction between social justice concerns and renewable energy…has only been taking place in that last two to three year period where there has been a noticeable push by governments…to develop the renewable energy sector as sort of stand-alone concept. …I think that what is really driving this [social justice concerns] is generally a sense that much of the renewable energy program is being imposed on people as opposed to something that communities have been evolving into… So that, I think has created a bit of an 'us versus them' mentality that in turn is perceived by a lot of people as basically a lack of social justice, given that the host communities really aren't active decision making participants in the process of how these projects are going to move forward. So… because of the perceived impact of renewable energy projects…. the phrase that is often used is 'it has become expropriation without compensation.' I think it is that sense of disenfranchisement that really is at the heart [of the issue] (professional 2).

Interviewees also recognized that local opposition is a key dimension of RE and that the topic is of great importance in an engineer's education, as awareness is lacking:

> I can put myself in those persons' shoes… …a ticking clock in a quiet room drives me nuts… So, if I am used to sleeping…hearing the sounds of nature and then there's whoosh, whoosh, whoosh…I can understand that they may have a problem with that (engineering educator 3).
>
> [So],…we certainly talk about [local opposition]… And I think that's a very good eye opener because the students very often are completely unaware that anyone is actually opposed to these technologies…so at least they may not have developed all the skill-sets to be able to know how to deal with it, but at least they know that that opposition does exist (engineering educator 1).
>
> [Overall,]…it's extremely important that they're armed with public opposition information…and I am finding more and more opposition to solar, too, which I find kind of fascinating… (engineering educator 3).

Engineers are involved in RE technologies in different ways. They design the technologies, or they design the actual deployments in RE projects. In the case of PV design, for example, significant *social justice* challenges exist across the technology's life-cycle which are associated with how materials are being circulated across manufacturing, use, and decommissioning sites. In the case of designing actual deployments in solar or wind projects, choices of scale and community ownership are key. In this chapter I focus *on the role of engineers in project development*, rather than the design of PVs or wind turbines, which is important as well.

To adequately address REE's implications for *social justice*, I argue that the RE engineer's competency portfolio must consist of (a) acquiring the engineering knowledge that is necessary for building technically sound RE projects; (b) acquiring the knowledge about environmental, political and legal implications of RE project development; (c) acquiring the knowledge regarding RE projects' *social justice* considerations; and (d) acquiring the knowledge to assess *and facilitate* community involvement in RE project development.

12.3 Who Counts as a "Renewable Energy Engineer"? The Status of *Social Justice* in REE Education

Engineers play a central role as designers, builders, and operators in energy systems. As they extend their expertise in electrical, mechanical and chemical fields from fossil fuel-based systems to RE systems, sustainability has become one of the key criteria engineers ostensibly apply in their work. The question is, how may engineering cultures and practices affect the realization of sustainability and SJ via technological systems? Nowadays, economic and environmental sustainability as expressed in concepts like *eco-efficiency* (World Business Council for Sustainable Development 2000) or *natural capitalism* (Hawken et al. 1999) have been the dominant policy narratives.

For example, a recent report by engineering educators argues that while "the analysis tools needed to evaluate economic metrics are generally covered in current engineering programs…," and "the tools needed to assess environmental metrics are covered in some engineering education programs…, *[t]he tools needed to evaluate social metrics are largely absent from engineering curricula"* (Allen et al. 2009, emphasis added). The same report, which aims to determine sustainable engineering's degree of integration into educational programs across the U.S., recognizes that "topical areas for [sustainability engineering] research are heavily concentrated in energy and power systems…" Nevertheless, the authors fail to consider the amount and characteristics of *social justice* content in engineers' undergraduate and graduate education.

In most engineering contexts, the statement "my engineering project contributes to social justice" is essentially meaningless. Unlike other professions, such as public health or social work, which ascribe meaning to *social justice*, engineering either excludes consideration of the "social" and "political" altogether, or relegates them to the periphery. Engineers are comfortable dealing with "facts," whereas values or feelings do not have a clear place in their profession. Most engineering students are exposed to professional ideologies that are connected to a particular way of knowing: engineering means evaluating knowledge objectively. This objectivity, when taken for granted, effectively reduces society to a set of numerical problems. Hence, any attempt to re-frame the discussion by considering "social justice" in engineering practices is fraught with status and credibility issues. As an illustration of the inherent difficulties in this endeavor, an engineer and *social justice* activist remarked:

> Social justice is not really considered in engineering. I think that sustainable development is and that is our framework for trying to say, 'we want to help people live better lives,' but we end up doing more harm than good. We don't necessarily care about the human aspect of it. So, I think it's been very hard to get social justice even considered as a valid topic to be talked about in engineering, period, let alone in renewable energy. Engineering and social justice is water and oil. [Therefore,] the credibility issue is a big thing because you need to be able to speak the language in your own dominion and across dominions, too. I found a lot of times I have to really frame my wording, 'okay this is how you need to do it as an engineer.' And when you do that [mention social justice] you are not considered to be a real engineer. I face a lot of issues in my department where I've been told that the work I am doing is not a real engineering project… (engineer-social justice activist 3).

According to one educator, *social justice* talk brings students out of their comfort zones:

> [Students] are brought up with a particular dominant discourse, within their schools, with their parents; [therefore,] questioning that discourse is painful. It really hurts them. In my course, any of them start to move through the threshold [of social justice], they are in my office saying, 'I don't like this. I am really unhappy. I feel horrible…' In a class of 100 students [even when social justice is] taught really, really well, you'll still get students hating you because they've been put out of their comfort zones… (engineer-social justice activist 1).

While the assumed non-political nature of technical work has made *social justice* a non-issue for engineers, the renewable, "clean" aspect of RE has led practitioners to believe that green technologies are inherently just. Therefore, any special consideration of *social justice* has no apparent place in RE. At best, proponents of RE may consider it redundant. At worst, they may worry that introducing the perspective of SJ may undermine the hard-won credibility and ethical status of green energy projects.

12.4 Why Renewable Energy Engineering?

A preliminary survey of the technically focused, RE-related, educational initiatives in the U.S. (see Appendix A) shows that REE is a new and relatively diffuse field that is a small fraction of the broader movement of RE education. Very few, if any, engineering educators positioned themselves as part of "sustainable engineering education." RE education is primarily taught by a minor subset of engineering educators. The vast majority of professionals are practicing REE without having had an organized educational foundation in RE. Moreover, the subset field of RE as the actual educational focus is only beginning to migrate into universities and engineering schools, as opposed to RE just as a product of engineering practice. Whether RE will become its own field of engineering remains contentious. Some educators felt that by "going too broad," one is likely to sacrifice the expertise that a practitioner derives from being a mechanical, chemical, or electrical engineer. Still, most educators argued that the holistic and interdisciplinary nature of RE contributes directly to the importance of RE knowledge and practice.

Although REE degrees are presently offered at only a handful of 4-year engineering programs, there is a proliferation of wind and solar energy programs, and certificates at both the community college and the engineering technology college levels. A possible explanation for this phenomenon may be that these colleges are much closer to the community level. They are less powerful and less prestigious—so, they are more free to experiment with REE. It may also be that some schools are trying to make a name for themselves by offering an RE program. Some engineering programs at universities like the University of Massachusetts at Lowell, Santa Clara University and Texas Tech offer graduate degrees in "solar engineering," "sustainable energy," and "wind science and engineering," respectively. It is quite common for REE education initiatives to be affiliated with research centers (e.g. Illinois State University, University of Massachusetts at Lowell).

RE education within the context of an engineering or technology department has its own historical trajectory. Solar PV was part of space engineering research development following the oil embargos of 1973 and 1979, and engineers were given opportunities to work on RE at the graduate level. Graduates could have worked on solar thermal applications in places such as Colorado State University or the University of Madison, they could have studied wind energy at Appalachian State University, or they could have studied alcohol-based fuels at Santa Clara University. This opening of opportunities in REE, mostly in research and development at the graduate level, paralleled the existence of traditional power engineering programs. But as the energy crisis diminished, many solar specialists, for example, were left unemployed. Consequently, although "around 1980 solar energy was taught in about 150 universities in the U.S.A…[in 2001] only about 10 universities [were] regularly offering solar energy courses…" (Goswami 2001).

Established in 2005, the Oregon Institute of Technology is the only engineering institution currently offering an undergraduate degree in REE—Alfred University's Inamori School of Engineering is presently working to add this degree as well. Several schools, including Alfred University and the University of Maine, are offering minors in REE; others, like Illinois State University and John Brown University have minors in RE technology and RE, respectively. In most cases, however, "alternative energy" or "renewable energy" degrees simply suggest add-ons to the more traditional majors in mechanical, electrical, and chemical engineering. Such integration, which according to some interviewees parallels the development of bioengineering, is due to either engineering professors' personal research interests or the geographic placement (e.g. Northeast) of the institution being more favorable to RE development.

12.4.1 Do Concerns About Social Justice Influence Who Counts as an RE Engineer?

Interview data confirms the hypothesis that most RE practitioners consciously abstain from engaging with issues of local opposition to RE projects as they do not consider it to be a part of their engineering work. SJ concerns have very little, if any, influence on what counts as "a renewable energy engineer." Most educators agreed that what the future of RE really depends on is "good engineering:"

> We, as engineering educators, have tended to isolate ourselves…from other disciplines. Those disciplines…focus on social justice. Social justice; another way of looking at it is public good. And it's really…a difficult question that people don't want to address (engineering educator 4).
>
> We don't consider social justice in the engineering component. …[W]e'll talk about burning coal and significant health issues, but I would not say that we go into that in any meaningful way. We'll hit them over the head with a few statistics, that's about it (engineering educator 5).
>
> The challenge for us was to develop a program that students could take and get a good technical working engineering knowledge of these technologies, and the economics, and all the other stuff that goes with it—the social implications and the political implications—we do very little of that. We are not trying to make them political scientists [just]…good, solid engineers (engineering educator 1).

Returning to my definition of the RE engineer's competency portfolio, I have found that, not surprisingly, educators' emphasis is primarily on building technical competencies. Social, environmental and public policy issues are also slowly finding their way into most programs, usually in the context of one-off introductory or "Energy and Society" classes co-taught by faculty in engineering and the social sciences/humanities. Although its importance is recognized, explicit consideration of local opposition to RE projects is absent from the RE practitioner's education.

> I don't think that [REE is] that different from any standard engineering discipline. The core sets of knowledge would be thermodynamics, statics and dynamics, fluid mechanics… (engineering educator 6).

> Policy? I think that's always the toughest thing for the students to do because it's so… nebulous…it's tough to…pull together a good background in that. [M]any of the [policy, issues] we talk about are accommodated in that…graduate class. (engineering educator 6).
>
> [W]e do have a class that focuses on the societal and social impacts of energy and what that means. We feel that it is important (engineering educator 1). And certainly we integrate regulation and legal concerns in there as well (RE technology educator 1).
>
> [But] taking active part in permitting and siting? Neither of those are in my areas. Public opposition—don't do any of that (engineering educator 6).

Interestingly, the topic of how to involve engineers in studying and carrying out community RE projects is also largely absent from the education of future RE practitioners. Engineers do not typically view RE as something pertaining to a local scale. Rather, they see REE as a national project of achieving energy independence.

> To be honest…it comes around to…some of the most valuable skills being the softer pieces. …the most crucial thing is that you can communicate the benefits and risks of the project (RE practitioner 3).
>
> A lot of people want us to…collaborate on small-scale community projects, and we're new, but there is a huge demand for that. But since we are less of a research based [school]… we're not involved from that perspective (RE technology educator 1).

REE thus has *social justice* implications which REE education has yet to assimilate.

12.5 Engineering and Social Justice: From Contestation to Integration?

Rachel Hollander, who directs the National Academy of Engineering (NAE) Center for Engineering, Ethics, and Society, summarized the status of *social justice* perceptions in American engineering as follows: "It turn[s] out that the question of engineering and *social justice* [is] a hotly contested topic…, while humanitarianism and engineering or engineering *and social responsibility* [is] not" (Online Ethics Center 2010, emphasis added). But while practitioners contest *social justice*, UNESCO claims that the challenges of globalization, poverty and sustainability lie at the center of engineering practice (UNESCO 2010). What, then, makes engineers view *social justice* as at best irrelevant, and at worst a hindrance to their activity? Why does *social responsibility* speak to the hearts of engineers, whereas *social justice* does not?

Other authors in this volume explain well the reasons behind engineers' resistance to *social justice*. Erin A. Cech's and Jon Leyden's chapters interpret the contested nature of *social justice* in engineering in terms of opposing values. The engineering profession's core values, the argument goes, are in direct conflict with values of *social justice*. Therefore, the introduction of *social justice* in engineering has been blocked by the ideologies of *meritocracy* (which argues that social inequalities are a natural result of a just social system) and *depoliticization* (which obscures the ways by which the products of engineering contribute to the creation or consolidation of power relationships in society).

To Cech and Leyden's arguments regarding why *social justice* remains a peripheral issue in engineering affairs, I would add two dimensions: the first draws on a historico-philosophical examination of contemporary engineering-specific Non-Governmental Organizations (NGOs); the second is derived from *Engineering Studies* scholarship on the engineering professional identity.

12.5.1 Engineering and Social Justice: Challenging the Engineer's Social Responsibility

In the late nineteenth century, American engineers framed their work as a professional activity that creates social good: as engineering historian Edwin Layton points out, this ideological claim was prompted by confusion on the part of the general public regarding the negative impacts of technology (Layton 1971). During the early phases of professional engineering development, the tendency to think of engineering as creator of social good resulted in a changed conceptualization of engineering's role in society: engineering moved from an implicit loyalty to the corporation to the now popular idea of engineering as "knowledge and skill for the enhancement of human welfare" (Mitcham 2009).

Concerns focusing on the long-term social and political implications of engineering projects have seldom had center stage in the mainstream of American engineering. On the other hand, relationships with clients and the conduct of engineering as a *business* have been central to the agendas of national and international professional engineering societies. History teaches us why most engineers consider *social justice* redundant: other discourses—particularly *social responsibility*—have long framed the activism and critique of even the most progressive forces inside and outside the profession.

"In carrying out any program which means greater responsibilities for our profession…," wrote Morris L. Cooke, reformer of mechanical engineering in the early twentieth century, engineers should take their chances against the forces that prevent practitioners from realizing their "professional calling" (Cooke 1916).[7]

[7] Throughout the nineteenth century, American engineers like Claudius Crozet, Andrew Humphreys and James Eads were individualists; that is, independent consultants or owner-engineers who built the nation's early transportation infrastructure (Reynolds 1991). These engineers were both culturally visible and socially praised, often celebrated as heroes, whose "values entered the national literature… once the national landscape burgeoned with engineering achievements" (Tichi 1987). By the beginning of the twentieth century, though, engineering in the United States had been transformed into a profession which was fully integrated into America's corporate system and whose practitioners were "organizational men" *par excellence*. This meant that engineers became largely invisible. In that sense, the concept of "the engineer's *social responsibility*"—an idea invented by American technocrats—is part of the effort by engineers to remedy the ever-increasing cultural invisibility of their profession.

In so doing, insurgent engineers like Cooke, but also organizations like the Scientists and Engineers for Social and Political Action (SESPA), have appropriated a discourse of *responsibility* to characterize their concerns. Since then, *social responsibility* has provided a convenient conceptual framework for engineering-specific NGOs, such as the Engineers for Social Responsibility (ESR). This framework has stimulated reflection on engineering and subsequent actions, thereby responding to an assumed "conflict between… [the profession's perceived] goals and… military and commercial interests" (Parkinson 2010). This partly explains Hollander's assertion that "[s]ome engineers d[o] not think social justice [is] an appropriate issue for engineering practice or for consideration in their societies" (Online Ethics Center 2010).

Table 12.1 (below) shows examples of the types of considerations that spur engineers to reflect on their social responsibilities. The table suggests that historically such concerns have clustered around various versions of the *social responsibility* approach.[8] The discourse on *social responsibility* has monopolized engineering reflexivity; but is it appropriate subject matter for engineers? Gary Downey and Juan Lucena, for example, have asserted that the knowledge contents of engineering are key if one wants to understand how engineering professional identities are formed (Downey and Lucena 2004). These authors suggest that "following the identity politics of engineers may provide a conceptual and methodological vehicle for mapping linkages between" questions like what it means to be an engineer and what it means to do engineering work. Downey and Lucena's concluded that "engineering [has been] a project for and about nations." Will the RE engineer have a different relationship with her publics; will she include local publics?

The contentious nature of *social justice* in engineering makes one wonder to what extent *social justice* considerations could be integrated into the profession's practice and education. Explicit connections between engineering and *social justice* have been outlined and debated primarily via the Engineering, Social Justice, and Peace Network's (ESJP) activist and scholarly initiatives, a mapping and categorization of which is offered in the first chapter of this collection. Throughout the twentieth century, engineering-specific NGOs construed *social responsibility* as a technocracy-inspired umbrella concept used widely, and quite diversely; but *social justice* brings genuinely novel concerns to engineers, as well as new ways of debating them.

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[8] Although the literature on *social responsibility* as it pertains to science is extensive, the appropriation of the concept by engineers and their communities deserves attention in its own right; such investigation, nevertheless, goes beyond the scope of this chapter. See Layton (1971), Moore (2008), and Wisnioski (2012). Wisnioski, who is primarily interested in what he calls *the intellectual crisis of technology* (1957–1973) in the U.S., uses historical evidence to document that since the progressive era, a *technocratic* conceptualization of social responsibility has been part of the American engineering culture.

Table 12.1 A discourse on *social responsibility* has historically monopolized engineering reflexivity

Actor	Period	Driving concerns	Discourse
Frederick Haynes Newell; Morris Llewellyn Cooke[a]	1912–1922	Application of the engineer's method to human affairs; industrial domination of engineering professional societies	*Planning or social responsibility; professional calling*
Thorstein Veblen[b]	1921	Critique against the "Price System" (i.e., capitalism and the business establishment)	*Instinct of workmanship*
Society for Social Responsibility in Science (SSR)[c]	1949–1976	Pacifism, military applications of science and engineering, free expression among scientists	*Social (and moral) responsibility*
Scientists and Engineers for Social and Political Action (SESPA) and "Science for the People" (SftP)[d]	1969–1989	Decoupling research from military, social and political aspects of technical work, engineering unemployment, engineering unions, genetic engineering	*Social responsibility*
Engineers for Social Responsibility (ESR)[e]	1983–	Nuclear weapons and nuclear waste, engineering unemployment, waste minimization, sustainability, indigenous rights	*Social responsibility*
American Engineers for Social Responsibility (AESR)[f]	1988–1992	Engineering ethics and nuclear weapons, economic conversion, the engineer and sustainability	*Social responsibility*
International Network of Engineers and Scientists for Global Responsibility (INES)[g]	1991–	International peace, nuclear abolition, sustainability, justice abandonment of military research	*Social responsibility*

[a]Layton (1962a), Cooke (1916)

[b]Veblen, of course, was no engineer, but an economist and social theorist who became interested in engineers in the second decade of the twentieth century. Veblen is credited with transforming the English word *technology* by incorporating into it the German concept of *Technik* (Layton 1962b; Schatzberg 2006). In his *Engineers and the Price System*, Veblen (1921, p. 93) was lamenting the fact that "popular sentiment in this country will not tolerate the assumption of responsibility by the technicians, who are in the popular apprehension conceived to be a somewhat fantastic brotherhood of over-specialized cranks, not to be trusted out of sight except under the restraining hand of safe and sane business men"

[c]See, for example AAAS (1953) and Unger (2010)

[d]See, Moore (2008) and Wisnioski (2003)

[e]John Peet and Gerry Te Kapa Coates of ESR, personal communication. For an introduction to ESR, see their website at: http://www.esr.org.nz/. In 1984 the "Society of Social Responsibility in Engineering, Australia" was founded. Inspired by ESR's vision, like-minded British engineers formed in 1989 ESR, UK, which in 1991 merged with Architects for Peace to form Architects and Engineers for Social Responsibility. Architects and Engineers for Social Responsibility merged with Scientists for Global Responsibility (SGR) in 2005

[f]Tom Munsey, Jim Evans, Gregory McIsaac and Orson Smith, personal communication; AESR newsletter, 1988–1992

[g]See INES' site at: http://www.inesglobal.com/ines-home.phtml. The word "justice" appears in INES' mission statement. INES was founded in order "to promote international peace and security, justice and sustainable development, and working for a responsible use of science"

12.6 Going Beyond NIMBY-ism in Thinking About Local Opposition: A Social Justice Assessment Framework for Renewable Energy Engineering Projects

> When local communities try to block installation of solar like they did in San Luis Obispo, we act to overcome the opposition…
>
> In Oakland I learned that some kind of opposition you have to crush… [y]ou can talk but you have to move forward.
>
> California Governor Jerry Brown, July 2011.[9]

California Governor Jerry Brown has advocated implementing a "centralized base of arbitrary intervention to overcome the distributed political power that is blocking this process [of building solar projects]" in California. This approach is characteristic of most RE proponents' conceptualization of local opposition to projects. Although the Governor himself realizes that "[p]ermitting presents the most significant challenge to a viable project," his perspective misses two issues: First, the mentality of "crushing the opposition" is unlikely to solve the core problem of numerous communities around the U.S. being unsatisfied with the way planning, siting and permitting of RE projects takes place. Much research has shown that attempts by politicians to realize RE projects despite local resistance (e.g. through speeding the permitting process) have only increased—not mitigated—community opposition (Wolsink 1994). Second, this mentality fails to perceive that opposition is the *result* of people being ignored, overrun and not actively involved in project development. A SJ *assessment framework* for REE projects premised on community participation and community ownership offers an alternative to both NIMBY-ism and the mentality of "crushing the opposition."

As regards local opposition to RE, two British-based academic projects ("Beyond Nimbyism," and "Community Energy Initiatives") and the resulting publications (e.g. Devine-Wright et al. 2009; Walker et al. 2010) have carved out a new area of research that is germane to the nexus between RE and SJ.[10] In 2007, *Energy Policy* devoted an entire issue to the "social acceptance of renewable energy innovation."[11] The first published work, which investigates RE project development through the lens of *social justice* theory, is Australian scholar Catherine Gross' article (Gross 2007). More recently, a combined distributive-procedural justice framework was employed by European researchers to examine RE development in Germany, Austria and Switzerland (Walter and Gutscher 2010). These authors argue that communities are significantly more positive about smaller projects. Publications such as Gross' article or the works which are coming out of the "Beyond Nimbyism" project reflect a particular policy climate in the authors' countries of origin, as well

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[9] Kahn (2011).

[10] For Beyond Nimbyism see http://geography.exeter.ac.uk/beyond_nimbyism/ and for "Community Energy Initiatives" see: http://geography.lancs.ac.uk/cei/communityenergyproject.htm

[11] See Wüstenhagen et al. (2007).

as a constellation of policy and NGO-related initiatives (Walker et al. 2007; 2010) taking place in the UK and Australia since the late 1990s.

I build on Gross' work to suggest an SJ *assessment framework* for REE projects. Gross rightly acknowledges the procedural approach as a way to increase the fairness and outcome acceptance of RE projects. However, her analysis reifies the role of technical professionals, who are absent from her discussion of "community fairness." Here I maintain that a relational approach to REE and SJ would necessarily have to include the interaction between the community and the technical experts involved in the development of an RE project.

RE technologies are highly complex systems with interrelated technical, sociopolitical and economic dimensions. In order to effectively address SJ in the RE sector, engineers, communities, and institutional actors like legislators or policy makers must be equipped to recognize the broad spectrum of SJ considerations in designing, implementing and sustaining RE technologies. Pioneering studies of local opposition to RE projects offer a critical general background in that vein. Recent research examines RE project development from the perspective of theories of distributive and procedural fairness—and suggests a starting point for exploring RE as it pertains to *social justice*. Yet, none of these works consider *social justice* from the perspective of the professional engineers involved in RE project development. Hence, engineering practitioners and educators need a preliminary conceptual framework to help them think through the possibility of implementing SJ monitoring and evaluation schemes specifically targeted at REE projects.

The literature's premises can be summarized as follows: (a) The degree of *community involvement* is inversely proportional to local opposition against the construction of an RE facility (e.g. Breukers and Wolsink 2007); (b) Despite their various interpretations of the role of "emotiveness" in project opposition, RE developers believe that *an ideal decision-making process* "*be kept strictly unemotional, objective and rational*" (Cass and Walker 2009, emphasis added). However, NIMBY-ism, which is often considered the main obstacle to RE growth, does not capture *the situatedness and multidimensionality of RE project opposition* (Burningham 2000). NIMBY-ism provides a rationale for rejecting any community concern that developers label "emotional" and for not taking seriously *social justice* questions such as: "What role should residents, old and new, play in determining landscape-technology compatibility, scales of design, pace of development and acceptable mitigation?" (Phadke 2011); (c) The *question of trust* between the community and the RE project's developer(s) is fundamental (e.g. Owen 2004; Raj Upreti and van der Horst 2004). Gross (2007), for example, associates trust with perceived fairness, arguing that "[p]eople who feel that they have been treated fairly are more likely to accept the decisions resulting from the process, and also will be more likely to trust the institution making the decision." In that context, what community members perceive as *fairness depends greatly on the communication of the risk(s)* associated with project development (Huijts et al. 2007). Among the groups involved in the development process, *technical professionals are those who are trusted the least* (ibid); (d) The concept of RE *"community ownership" is shown to have multiple social and economic benefits* in wind (Lantz and Tegen 2009) but also in solar energy (Farrell 2010). Farrell, for example, argues that businesses and

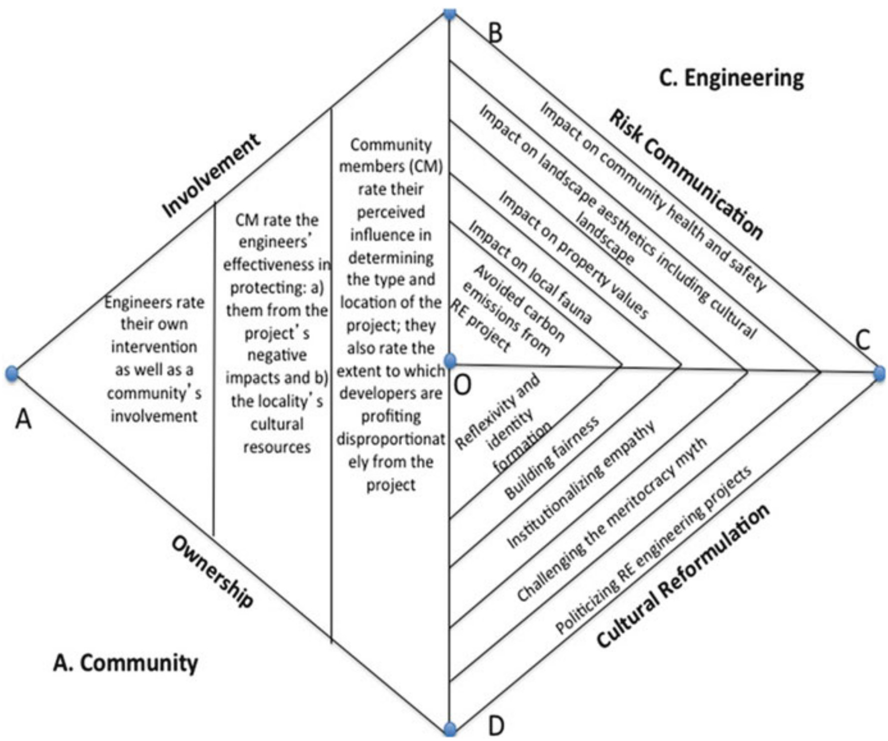

Fig. 12.1 A social justice assessment framework for renewable energy engineering projects

communities could benefit from project ownership and become energy producers; they could also become consumers involved in defining the trajectory of the post-carbon energy system. The distribution of economic and social benefits would mirror the distribution of project ownership.

Hence, a qualitative and participatory approach would be the most effective means of exploring the SJ considerations in a given RE project-development. Below (Fig. 12.1) is my proposed, survey-based, SJ framework for re-conceptualizing RE opposition in terms of fair, trusted and empathy-based interactions between members of the affected community and the engineers involved in project development. The framework's philosophy is based on the four premises outlined above. The framework gives a voice to communities, alongside engineers. It requires engineers to go through a rating exercise to evaluate how well they are addressing various facets of RE project development. The approach's limitation—its reliance on self-reported data—may also be its major strength.

The framework's basic components include, on the one hand, "Community" as it pertains to the goals of "Involvement" and "Ownership." On the other hand, the framework examines "Engineering" in relation to the processes of "Cultural Reformulation" and "Risk Communication." The "Community" and "Involvement" triangles refer to data obtained from surveys of community members and engineers. "Risk Communication" and "Cultural Reformulation" refer to the knowledge communicated between technical experts and community members, and to the ways RE engineering cultures could redefine themselves, in order to increase the levels of trust and fairness in the process of RE projects' risk communication.

Three types of rating are suggested for measuring community members' perceived involvement with, and ownership of, a project (triangle ABD). First, community members will rate themselves as having more, less, or no influence in determining the two key parameters in RE project development: *type* and *location*. The case for communities' involvement in siting and permitting (procedural justice in RE) raises the important question—addressed below—of assessing the participatory approach's actual impact on project development. One way engineers can contribute to procedural justice in RE is by documenting the quality and end-result of community involvement.

The second type of rating concerns the conflicting nature of the siting and permitting procedures, which are associated with perceived injustices as regards the distribution of RE projects' impacts (distributive justice in RE): the community is expected to rate the extent to which its members perceive that engineers, developers but also other members of the community are profiting disproportionately from the project. Although the procedural justice discourse in RE has focused on controversies between "community" and "developers," the framework outlined above invites engineers to consider conflicts between community members as well as conflicts between technical professionals (e.g. engineers may oppose an RE project for reasons they deem "technical" or "environmental").[12]

Third, community members will rate the engineers' effectiveness in protecting (a) the community from the project's negative implications and (b) the locality's cultural resources (triangle OBC). According to Sydne Marshall, Cultural Resources expert with Tetra Tech, an environmental engineering firm in Pasadena, CA such resources include "archaeological sites, standing structures, cultural landscapes, and traditional cultural properties" (Marshall 2011). Marshall argues that managing cultural heritage increases connection with local communities. Hence, "… by sponsoring field surveys to identify archaeological sites, historic architecture, cultural landscapes, and traditional cultural properties…" developers increase the likelihood that projects "becom[e] more integrated into the local community…"

Triangle OBC illustrates the main stakes as RE project and its siting-permitting progresses. Public concerns regarding RE project-development are accommodated

[12]The initial plan for a proposed wind project in Spanish Fork, Utah, for example, was objected to by a local city-engineer who thought that "the construction might interfere with the city's nearby springwater collection system" (Hartman et al. 2011). However, an alternative plan, which required that the turbines be located closer to people's homes, was resisted by community members. Finally, an independent consultant engineer's determination that the project would not harm the local water supply re-qualified the initial siting plan.

through siting and permitting processes which the industry considers basic determinants ("second only to incentives") of its growth pace. Although RE developers hasten to emphasize the economic benefits of RE (e.g. local employment) along with the environmental benefits of CO_2 emissions' reduction, in some cases communities have perceived such arguments as "simplistic" and have thus increased their opposition to projects (Raj Upreti and van der Horst 2004). On the contrary, resistance against RE has centered around the following themes: health and safety, landscape aesthetics (including cultural landscape), local flora and fauna, and property values. Such themes are part of an RE project's Environmental Impact Assessment (EIA) (e.g. Tsoutsos et al. 2005).

The importance of engineering facilitation and assessment of community involvement, and their actual impact on RE project development, seems obvious. Although the literature shows that RE project development should ideally be based on community involvement, no paradigm currently exists for how engineers can contribute to facilitating and assessing community involvement in RE. An inventory for community involvement is key if local participation is ever to be taken into account as a standard practice in RE. In that regard, engineers have much to learn from health practitioners' work, which in the last two decades or so has had an important element of "user-involvement."

Adapting from recent findings (Wright et al. 2010) in the field of public health, I propose that engineers could contribute to SJ through facilitating and inventorying community involvement in RE project development. To do this, I argue, they must consider their response to the following questions:

1. Why community involvement? Engineers and community members should be clear on the rationale behind community participation, for many developers approach community involvement simply as the "golden rule [of being] a good neighbor" (AWEA, Small and Community Wind Conference 2011). Clarification of the rationale includes the *timing* and the *degree* of involvement in the course of developing a RE project;
2. What types of tasks and/or interventions does community involvement actually translate into? What is the nature of these tasks? Will positive outcomes be monetary only? Are those tasks related to considerations of the siting/permitting decisions?
3. To what degree does community participation become institutionalized via the siting and permitting components of project-development? Do community members take part in the research or writing of the EIAs? Do they get credit for such intervention?
4. What metrics, if any, have engineers used to evaluate community involvement in RE (effectiveness of risk communication, division of labor in regulatory procedures, reformation and speeding-up of the permitting process, decrease of developers' costs, etc.)?

The suggested framework will encourage technical practitioners and social groups to communicate with the purpose of increasing RE engineers' accountability for their choices vis-à-vis the affected communities.

12.7 Conclusion

In this chapter I present a preliminary mapping of the developing REE field in the United States through the analytic lens of *social justice*. I discovered that *social justice* conceptualizations are largely absent from the education and practice of engineers involved in solar and wind technologies. Given that the social dimension of sustainability continues to be overlooked, the issue, then, is how can a broader understanding of sustainability be promoted amongst engineers. Renewable energy educators, students, and practitioners should be thinking about ways through which social justice issues and sustainability issues may be developed in tandem. I explore several aspects of what I call an SJ *assessment framework* for REE projects, premised on community involvement and community ownership. I argue that RE engineers can work for *social justice* by inventorying community involvement and assessing its actual affect on RE project development; the suggested framework could help engineers negotiate their path beyond arguments of NIMBY-ism and beyond a sole preoccupation with their projects' "legal compliance." The proposed assessment framework challenges a business as usual scenario. The issue, then, is how such a framework is to be implemented. Would the engagement with the local community as proposed be given legal force in the same (problematic) manner as EIA's? To do so would require that engineers focus on the policy context and look at ways they can reshape that context to enable them to facilitate the kind of procedural justice proposed in this chapter.

Appendix A

Preliminary overview of renewable energy technical education in the United States:
Renewable energy-related programs, degrees and certificates at universities (engineering, engineering technology, and other)[13]

Institution	Affiliation	Degrees Offered
1. Alfred University	Inamori School of Engineering	Minor in "REE" (the school is also working to add an REE major in Fall 2012 that is pending approval from the New York State Department of Education).
2. Appalachian State University	College of Fine and Applied Arts Appropriate Technology Program	BS, minor and MS in "Appropriate Technology".
3. Arizona State University	College of Technology and Innovation	BS in "Electronics Engineering Technology" with a concentration in "Alternative Energy Technologies".

(continued)

[13]The list does not include programs in community colleges.

(continued)

Institution	Affiliation	Degrees Offered
4. Arkansas State University	College of Agriculture and Technology	Bachelor's in Applied Science (BAS) in "RE Technology," with emphasis courses in wind and bioenergy.
5. Colorado School of Mines	Geoscience and Resource Engineering	Minor in "Energy" with a curricular track in "RE".
6. DeVry University	College of Engineering and Information Sciences	BS in "Electronics Engineering Technology" with a specialization in "RE".
7. Ecotech Institute[a]	Solar/Wind Energy Technology	Associate's degrees in "Solar Energy Technology," and "Wind Energy Technology".
8. Illinois State University	Department of Technology	BS in "RE".
9. John Brown University	Department of Renewable Energy	BS in "RE".
10. Lawrence Tech University	Alternative Energy Engineering	Undergraduate Concentration and Certificate in "Alternative Energy Engineering".
11. Oregon Institute of Technology	Renewable Energy Engineering	BS and MS in "REE".
12. Penn State University	Department of Energy and Mineral Engineering/Undergraduate Program in Energy Engineering	BS in "Energy Engineering" and minor in "Energy Engineering" with coursework in RE. The department also offers an on-line BA in "Energy and Sustainability Policy"; it is also developing online courses for University-wide Professional Masters in "RE and Sustainability Systems".
13. San ta Clara University	Engineering School	MS in "Sustainable Energy".
14. Stanford University	Department of Energy Resources Engineering	BS, MS, and PhD in "Energy Resources Engineering".
15. State University of NY, Canton	Alternative and Renewable Energy Systems Program	BS in "Alternative and RE Systems Technology".
16. Texas Tech University	Texas Tech's Wind Department	BS in "Wind Energy" (for non-engineers), "Wind Energy" Undergraduate Certificate, "Wind Energy" Minor or Area of Concentration, "Wind Energy" Graduate Certificate (Technical or Managerial Track). A doctoral degree program in "Wind Science and Engineering" has operated since 2007.

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Institution	Affiliation	Degrees Offered
17. University of California at Berkeley	Energy and Resources Group	Minor in “Energy and Resources”.
18. University of Delaware	Department of Mechanical Engineering	Research area in “Clean Energy” as part of the BS in mechanical engineering. This includes a course in wind energy.
19. University of Maine	College of Engineering/College of Natural Sciences, Forestry and Agriculture	Minor in “REE”.
20. University of Massachusetts at Lowell	Graduate Program in Energy Engineering	MS in “Energy Engineering” (Solar Engineering Option)
21. University of Massachusetts at Amherst	The University of Massachusetts in Amherst Wind Energy Center	MS and doctoral degrees in “Wind energy” plus a 15-credit graduate certificate in wind energy.
22. University of Nevada at Reno	College of Engineering	Minor in “RE” (Two tracks: one for engineering students, another for non-engineering students).
23. University of North Texas	Department of Mechanical and Energy Engineering	BS in Mechanical and Energy Engineering with a Research Cluster in “RE and Conservation”.
24. University of Northern Iowa	Department of Electrical Engineering Technology	BS in Electrical Engineering Technology with coursework in “Wind Energy Engineering”.
25. University of Texas at Austin	Renewable Energy Program to be launched in the Spring semester of 2012.	
26. University of Toledo	Department of Mechanical, Industrial and Manufacturing Engineering	Minor in “RE”, BS in Mechanical, Industrial and Manufacturing Engineering.

[a]Private

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Part VI
Synthesis and Conclusions

Chapter 13
The Road Ahead: Questions and Pathways for Future Teaching and Research in ESJ

Juan Lucena

Keywords Engineering education • Social justice • Educational reform

The goals of this book are to begin mapping and charting new territory for scholarship/activism in engineering and social justice (ESJ) and to attempt new connections and strategies in what is perhaps one of the most traditional and resistant-to-change areas of higher education: engineering education. The reasons for this resistance are complex and many and have been studied by scholars from historic (Wisnioski 2012) and organizational (Merton et al. 2004) perspectives. My own book (Lucena 2005) documents how historical events –mainly Sputnik, the Cold War, the end of the Cold War, the emergence of global economic competition-shaped the socio-political environment of the US and brought significant changes to engineering education. In this book, it became very clear that change in engineering education is difficult and elusive. So if significant geopolitical and/or economic events are needed to bring change to engineering education, what hope does the group of scholars committed to ESJ represented in this book have to bring any change to engineering education for the goals of social justice?

Perhaps we are not waiting for a historic event with the significance of Sputnik or the end of the Cold War. We are cognizant of the enormous challenges we face to change the hierarchy structures, reward system, processes, ideologies, pedagogies, curricular organization of the entire enterprise of engineering education. Yet knowing this, we still attempt to affect change from the bottom up, in our own institutions, courses and spheres of influence, as small as these might be. We try to be examples for our students and faculty peers of the change we want to see in the world.

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In concluding this edited volume, I would like to honor its authors by outlining the legacy that their chapters leave for other scholar/activists who might want to follow our footsteps by continuing or initiating new research or curricular pathways in ESJ. Each chapter has opened new lines of inquiry, possibilities for activism, and hopes for the future. Here is how.

13.1 Mapping and Surveying ESJ

Dean Nieusma's chapter (and Riley 2008 before him) has made it clear that social justice has *multiple meanings and interpretations* in fields of practice like engineering. Hopefully, this revelation will invite others to investigate what those meanings and manifestations are in different places in engineering education and practice. For example, Nieusma's chapter implicitly invites others to research important questions: How do other engineering organizations, like Engineers Against Poverty (EAP) or Engineers for a Sustainable World (ESW), understand social justice and put engineering into practice to correct injustices? How many and what kind of organizations like these are out there perhaps making, or with the potential to make, significant incursions in the engineering curriculum and practice? Does it make sense to organize and channel the efforts of all these groups so we can learn from and collaborate with each other? If so, how?

One way to approach these questions might be for those of us closer to ESJ to reach out and engage groups who have social justice closer to the center of their agendas and make their issues visible in engineering education. Some of the authors in this book have engaged organizations like National Association of Minorities in Engineering Program Administrators (NAMEPA) and National Organization of Gay and Lesbian Scientists and Technical Professionals (NOGLSTP) to do just that.

Nieusma also calls our attention to *pedagogical initiatives* as practices with the possibility to further social justice in the engineering classroom. All of those listed in his chapter are worth exploring further, researching and expanding. Yet one that has significant potential for furthering the goals of ESJ is *experiential learning*. Nowadays STEM reformers and educators are paying increasing attention to experiential learning as a strategy for recruitment and retention by "making learning fun," interesting and relevant.[1] Yet, experiential learning also presents a great possibility to heighten awareness of social justice and its connection to engineering. For example, there is a local project on *Engineering by Doing* at my institution, involving middle-, high- school, community college and university engineering students, to design a renewable energy source to power a water treatment plant. Throughout the multiple hands-on and design activities in this project, students can be challenged to consider multiple social justice questions: Who gets clean water via renewable energy and who does not? At what social, economic and environmental

[1]See Prince (2004) for a comprehensive review of experiential and active learning strategies in engineering education.

costs? Why do research universities tend to undervalue the knowledge and skills of those who come from community colleges? Why are middle and high schools from poor communities so ill equipped to engage students in pre-engineering activities? What kind of power structures and interests might be at play in keeping this kind of educational activities away from k-12 curricula?[2]

Nieusma's mapping also highlights *institutional initiatives* as places where those committed to ESJ can make a difference in projects, collaborations and programs by ensuring that social justice becomes a visible and important dimension of institutional life. For example, some of us in this volume ensured that social justice remained a visible and explicit dimension in a large NSF-funded grant on Climate Change, Engineered Systems and Society by engaging Native American tribal communities as they face an unfair and unjust challenge: they contribute less to CO_2 emissions than non-Native populations yet their livelihoods are more likely and significantly impacted as their engineered systems are more vulnerable to climate change.[3]

13.2 Lines of Resistance

Donna M. Riley's chapter makes us wonder how many other engineering students and faculty share similar experiences and struggles with the curriculum and the culture of engineering education as she has experienced throughout her career? Although most diversity efforts have made visible struggles of heterosexual white women, black men and women, there are ongoing, yet mostly hidden, struggles of people in engineering from lower socio-economic classes, diverse levels of disability, sexual orientations, and religious orientations. For example, in my Engineering and Sustainable Community Development class, an elective for engineering majors, low-income students who transfer from community colleges experience significant conflict between their desire for a high GPA, which they see as a ticket to a high salaried corporate job, and a commitment to solve problems in the disadvantaged communities where they come from. Unfortunately, some of these students come ill prepared and have to make difficult curricular choices, e.g., drop my class which is an elective, drop other engineering courses and increase the time and cost required to complete their studies, or stay the course and consider alternative career pathways. Like Riley, what strategies might students who are struggling and yet committed to social justice be using? At what economic, ethical and emotional cost? Might students who are resisting the injustices of the curriculum be organizing themselves in ways we do not know about? For example, engineering students of diverse political and sexual orientations have organized open mic nights, zine sites and blogs as spaces where they can share experiences, connect with others and contest injustices in their education.

[2] For example, see McLoughlin (2012) for a detailed analysis of the challenges that community college students face when transferring into engineering programs.

[3] See Intertribal Climate Change Working Group (2009) for comprehensive analysis of how climate change affects tribal communities disproportionately.

Also we can learn from them and channel their energies and experiences to reform the curriculum, its practices and the mindsets of the people in charge of engineering education. For example, after Riley's and Cech's visits to my campus, I found it easier to invite faculty and students, who had never openly expressed commitment to ESJ, to participate in workshops and activities related to social justice. After a faculty workshop heavily influenced by Riley's work, I can now engage a larger group of engineering faculty to talk about how to integrate ESJ into engineering sciences and design courses. And some students have been more willing and eager to speak out about their struggles and strategies related to their sexual orientations and the culture of engineering thus making social injustices visible to others.

13.3 The Ideologies of Engineering Education: Meritocracy and Depoliticization

Erin A. Cech's chapter invites us to reflect about where and how these ideologies are manifested in the curriculum. Interestingly, after reading Cech's work, students in my ESJ class realize how the ideology of depoliticization –the set of ideas and beliefs that describe and prescribe engineering as a "technical" domain where "social" or "political" issues such as inequality are tangential to engineers' work—is manifested and operates in the world around them: in the physical layout of their campus (e.g., engineering offices and classrooms in one building vs. liberal arts in another), in the organizations and language used in official school bulletins and catalogs (e.g., required "technical" courses vs. less important "social" and extra-curricular activities), in admission processes and practices (e.g., rankings of students and granting of merit scholarships according to GPA), and, of course, in the curriculum and in students' attitudes towards it (e.g., scheduling the required technical courses first and fitting conveniently scheduled liberal arts course later). Yet we know very little about how students experience these ideologies. Do they embrace them blindly? Do they resist them and try to challenge them? Or do they integrate the technical and social dimensions of their education in novel and unexpected ways? If so, how?

My anecdotal experiences with the ideology of depoliticization are mostly limited to my own experiences and to the courses where I make these visible to students. After graduating from engineering, I decided to pursue a career in STS and have built courses, programs and scholarship with the explicit goal of challenging this ideology. In my courses, students learn that the organization and content of engineering knowledge, viewed by students purely in technical terms, are actually shaped by social, political and cultural forces. They also explore how the main method of engineering problem solving (EPS), also viewed by students as a neutral and objective technical tool, has significant political implications due to what it hides and makes visible. When they begin to see that the boundary between the technical and the non-technical can be lowered, manipulated, or even hacked and disrupted, they seem both empowered and threatened. But how do they carry on in their lives after they make this discovery? How do they negotiate both empowerment and threat at the same time? We do not know—yet. So we need more research that would help us mentor students through their struggles and hopefully propose and implement curricular reforms accordingly.[4]

13.4 Buddhism and Engineering

Marisol Mercado Santiago's chapter challenges us to consider what engineering, particularly engineering design, can learn from Buddhism. Hers is a courageous attempt to connect and reconcile two fields of practice that historically and philosophically are far apart. She herself is trying this reconciliation in her own teaching and dissertation research of a pre-college engineering course in Tibet. Yet her intent to bring these two forms of practice together might not be unique. With the explosion of engineering degrees, programs and institutions in countries that have a deep-seated tradition of Buddhism (e.g., Cambodia, China, Japan, Thailand, just to name a few), how might others be trying to integrate Buddhism and engineering in these countries? Who might be trying this reconciliation? And for what purposes and what cost? This is clearly an area ripe for research and scholarship.

The practice of Buddhism in engineering is certainly no easy task. For example, the practices of Buddhist virtues, especially *patience*, would certainly challenge all US educators, not just engineers as our institutions adopt processes and policies that challenge educators with the logics of productivity and efficiency: to attract more students, teach larger classes, and graduate them in less time. Yet some of these virtues can be more challenging for engineering, which privileges the coupling of ideologies of economic competitiveness and employability in engineering; that is, the idea that we need to graduate more engineers quickly to join the workforce so our country can compete globally. Clearly, such privileging creates more difficult conditions in engineering than in other fields. But what might engineering be missing by allowing these ideologies to dictate the pace, and often the content and pedagogy, of education?[5]

Santiago's attempt also raises another key point: What would engineering design based on the Fourth Noble Truths look like? Would it be feasible in an industrial corporate setting? If so, at what cost to the company and to those attempting it? What kinds of technologies would this kind of design produce? Would these technologies be in fact more socially just, as Buddhist Venerable P.A. Payutto claims in

[4]James Huff, a doctoral student in engineering education at Purdue University and assistant director of Purdue's EPICS program, is undertaking research on how engineering students integrate the technical and social dimensions of their education.

[5]See Lucena (2005), especially chapter 4, for a history of how since the late 1980s economic competitiveness has become the main preoccupation of engineering educators after engineering policymakers introduced the "pipeline" as a conceptual model to quantify the number of students, and their behaviors (interest, recruitment, attrition, graduation, continuation into the workforce, etc), going into STEM fields. This preoccupation still persists today at the highest levels of policymaking (see Anon. 2011).

his call for "constructive technologies" that are moderate, used for creating benefit, and serve to develop understanding and improve the human being (Payutto and Payutto 1993)? Although other design traditions have attempted to reconcile with Buddhism (Mellersh-Lucas 2012), as far as I know this has not been tried in the practice in US engineering design.

Also by mapping the stages of engineering design against a Buddhist-based leadership model, Santiago provides yet another pathway for including communities in engineering projects. This new form of *participatory design* might be a welcome approach to community participation and inclusion, especially in cultural contexts where Western participatory approaches have come under suspicion (Cooke and Kothari 2004). With so many engineering for community development projects going on in Nepal and South East Asia, initiated by US based organizations like Engineers Without Borders (EWB), one can only wonder if Santiago's framework would give these projects a better chance of success. Research on the outcomes and effectiveness of this framework will be most welcomed.

13.5 Caring in Engineering

Taking Ryan C. Campbell's definition of caring as "active compassion, empathy and concern for wellbeing of others," how would an engineering of care look like? How would caring engineers behave and practice? What kinds of systems and artifacts will they produce? And would these be more socially just? Campbell acknowledges that there have been previous attempts to formulate an ethics of care in engineering (Kardon 2005). Yet caring, as defined here, has not made inroads into engineering codes of ethics, the mainstream of engineering ethics education, and only superficially and implicitly in engineering organizations like EWB and ESW. Interestingly, this year in my school there is a renewed interest among engineering students to design artifacts to address needs of handicapped people. Even though caring is not explicitly listed as a motivation, these projects are a good start, as physically able students will be challenged, I hope, to show compassion, empathy and concern for the wellbeing of their disabled clients. Yet I can only wonder to what extent the assumptions made in a course created mainly for industrial clients would apply to situations of care.[6]

Since many of the readers of this book are probably connected to humanitarian engineering, community development engineering programs and/or engineering ethics education, might they be wondering what their programs would look like if they were to adopt Tronto's framework—based on attentiveness, responsibility, competence, responsiveness, and integrity of care—as a part of a framework for

[6]See chapter 3 in Lucena et al. (2010) where we question the validity of these assumptions. Also, see Lucena (2013) where I question the implications of engineers viewing people as "clients" especially when designing in a relationship of care such as the one that exist between engineers and disabled people.

desired competencies of our engineering graduates? Or how would an ethics of care enhance engineers' ability to see injustices and engage in social justice? Might *caring* be an antidote to the blinding effects of the engineering mindsets as described by Rilley (2008) while making engineers better contextual listeners, as two of us have suggested elsewhere (Leydens and Lucena 2009)? And what can engineering learn from professions that have a more explicit ethics of care such as public health and social work (Parker 1999)?[7] Also, if adopting Buddhist principles, as suggested by Santiago, proves elusive because of the vast cultural distance between Buddhism and engineering (at least as practiced in western industrialized societies), might a western ethics of care achieve similar results as those sought by Santiago?

So Campbell, and those who will follow his steps, have the interesting challenge of continuing to develop a framework and criteria for an *engineering of care* that could explicitly guide engineering ethics and design courses, community development projects implemented by engineers, learning through service (LTS) in engineering activities like those represented in the ASEE division of Community Engagement, and pedagogies in the engineering classroom.

13.6 Threshold Concepts

As with Cech's chapter, Caroline Baillie's and Rita Armstrong's chapter challenges us to question the "common sense" ways of thinking in engineering, particularly with respect to social welfare and justice. The authors contribute to our understanding of why and how engineering students "do not get it" and resist when we try to teach them about social justice. Their work on *threshold concepts*—those transformatory concepts which students in a discipline, such as engineering, need to understand in order to enter a different disciplinary way of thinking, such as sociology of inequality—is important as it raises a number of key questions about how to identify these concepts in our own teaching spaces and, once identified, how to make them relevant to the practice of engineering.

First, Baillie and Armstrong recognize that "the emergence of knowledge about thresholds, however, did not only come from within the disciplines but between the disciplines." Hence they invite us to engage in further interdisciplinary work and collaborations to find out what else might our engineering students need to know to see and understand social injustices and the causes of inequality. Furthermore, their work also challenges us to investigate how, after learning threshold concepts, engineering students might make connections between engineering and injustices/inequalities and how to put engineering at the service of social justice. Who among

[7] I have begun experimenting in my engineering classes with the work of Dr. Rachel Remen on the difference between help vs. service and on the need to restore a sense of service in the professions in order to counteract what Donna M. Riley has accurately labeled "the desire to help and the persistence to do it" as one of the engineering mindsets that blind students from seeing social injustices. See Remen (2001).

us and how are we, as engineering educators, best suited to partner with other disciplines in order to make new threshold concepts and connections visible? Should we partner with social workers, community leaders, homeless persons and/or disabled persons in order to elicit new threshold concepts that, when learned, will allow our students to see the world in a different way?

Second, Baillie and Armstrong also invite us to consider what kinds of attitudes educators and students need to develop in order to move beyond resistance and begin seeing their importance. They call for significant attitude change including "humility, empathy and interest." There are interesting similarities here with Santiago's chapter on Buddhism and Campbell's chapter on Caring. These chapters seem to be in agreement that acting with humility and empathy will help engineers learn and acquire threshold concepts, see beyond their thought collectives and, perhaps more importantly, design and develop socially just technologies.

Third, Baillie and Armstrong also raise the question of who might be best suited to teach these threshold concepts. In their case, it was a pair of engineering and anthropology professors. But this combination does not exist everywhere. So what are engineering educators without access to social scientists (or vice versa) to do? Realizing that practicing engineers can be quite effective in the classroom, I often invite engineers to my class who can relate to students identities and professional desires and who might have moved beyond the constraints of the engineering thought collective. These are engineers who already use threshold concepts in their thinking and deploy them in their practice. For example, after having taught the concept of "self determination" in community development from the rural studies literature (Bridger and Luloff 1999), something that some students resisted, I recently invited a mining engineering executive turned humanitarian engineer to speak to my class about how important it was for communities to have "self-determination" in their own affairs and livelihoods after a particular mining project was put in place. The concept not only became alive for students, as it was presented to them through an engineering example, but because it came from an engineer with whom many could identify, even students with paternalistic and authoritarian inclinations began considering "self determination" of communities seriously.

Finally, collectively those of us committed to teach ESJ should be considering further work in threshold concepts. In understanding ESJ core principles, what tend to be common, crucial turning points—threshold crossings—for engineering students? What else do our students need to know to develop new knowledge, skills, attributes and attitudes that will enable them to engage in social justice work? This could clearly become the subject of future conferences and research but let me propose two possibilities here. In order to see social injustices and possibilities for engaging in social justice, engineers need to understand what engineering mindsets are, where they come from, and how and why they exist in engineering settings.[8]

[8]Donna M. Riley has outlined these engineering mindsets as (1) dominance of military and corporate organizations, (2) uncritical acceptance of authority, (3) positivism and the myth of objectivity, (4) desire to help and the persistence to do it, and (5) technical narrowness (Riley 2008).

They need to cross this conceptual threshold to find ways to transcend their influence and engage in social justice work. In my ESJ class, I have found out that when students understand that engineering mindsets can act as blinders, that these have a history, and that they are alive and well in most engineering settings, including students' own engineering schools, students begin to see the world differently. Another example of a threshold concept related to social justice is the concept of "privilege," both earned and unearned. In order to help students see these, I conduct a "privilege walk" (Rothenberg 2003, chap. 20; Cooper et al. 2011, chap. 2). After the privilege walk, students begin to see the relationship between privilege and inequality but do not understand what maintains these in place. This is where they need to become aware of yet other threshold concepts, i.e., the ideologies of meritocracy, heteronormativity, and depoliticization (see Cech and Waidzunas 2011 and Chap. 4 by Cech in this volume).

13.7 Connecting the Forgotten

Jen Schneider's and Junko Munakata-Marr's chapter challenges us to wonder how many places like Sun Valley exist near our engineering schools. If the authors' curricular/pedagogical intervention arose from preoccupations about engineering schools irresponsiveness to the injustices that confront local neighbors, they invite us to ponder how we can incorporate in our engineering courses meaningful and transformative experiences for both students and communities in ways that begin to alleviate injustices and inequalities.

Local projects in financially poor communities present engineering schools and students with unique challenges and opportunities. While projects abroad, like those often pursued by EWB, happen in remote locations not directly tied to our voting and taxation practices, local projects confront us with our own responsibilities over own neighboring communities. How we vote, what taxes we support, what petitions for local action we sign, how much money local government spends on campus infrastructure vs. poor communities, etc., all have social justice implications as these actions impact how resources, opportunities, risks and harms are distributed among different local demographic groups. When Schneider and Munakata-Marr confronted their class with socio-economic data of Sun Valley residents (e.g., data about poverty, single parent homes, literacy, etc.), one can only wonder how students experienced beyond the course questions: Why is there so much inequality in our own backyard? What are the sources of these inequalities? How can I put my privileged position as an engineering student to use in alleviating inequalities? In a similar way that Baillie and Armstrong claim that threshold concepts transform students, might Schneider and Munakata-Marr be giving us insights into the kinds of *threshold experiences* that will transform students and make them more receptive to engage in social justice issues?

But more than transforming students, local interventions also have the potential to challenge the core ideologies of engineering. International projects for engineering students are in large part motivated by (and also reinforce) the ideologies of employability, meritocracy, and depoliticization in engineering. Projects abroad often add value to students resumes, enhance schools' public image and international reputation, are available to students of certain GPAs and income, and are often assumed to be apolitical and beneficial acts of aid of the Global North to rescue Global South. The lasting, long-term value of such projects for local communities generally remains unknown.[9] But local interventions, as those attempted by Schneider and Munakata-Marr in their class, have the potential to challenge these ideologies as students, faculty, administrators (like those in charge of career services, for example) will be confronted with questions like

- how would involvement in a local project in a poor neighborhood help students' career, resumes and employability?
- if graduates want to continue working as engineers in these communities, would school career services have to shift some of its focus from corporate to public or NGO employment? If so, at what cost to the school's reputation?
- if schools do not respond to students' desires to work with communities, might students themselves be able to start their own NGOs or community organizations (see Chap. 11 by Arias, this volume)?
- if geographical and cultural proximities make communication with local communities relatively easy and regular, how can we ignore them as partners in problem definition and solution?

Existing innovative programs in local community service in engineering education, such as Purdue University's Engineering Projects in Community Service (EPICS) (Coyle et al. 2005), would be ideal collaborators to enter into a dialogue with ESJ scholars on how to address these and other social-justice related questions.

13.8 Integrating Social Justice from the Margins

Jon Leydens' chapter invites us to consider integrating social justice in all levels of the engineering curriculum: foundational core, design, engineering sciences and humanities/social science (HU/SS) electives. Among the authors in this edited collection, there are exemplary cases of this integration. For example, Baillie and Armstrong have written a book for Introduction to Professional Engineering which introduces engineering students to sustainability and social justice issues related to engineering practice by contrasting the way engineers deal with waste in three countries: Argentina, India, and Australia (Armstrong et al. 2011). In the engineering sciences, Donna M. Riley wrote a companion book that can be used in any thermodynamic class with the goal of introducing teachers and students to social

[9] See Nieusma and Riley (2010) for a thoughtful analysis of how these projects might make injustices invisible to students and, in some cases, actually reinforce injustices.

justice, among other dimensions related to energy (Riley 2011). In design education, the Design, Innovation and Society (DIS) program at Rensselaer Polytechnic Institute (RPI), where Dean Nieusma teaches, serves as exemplar in engineering design education with significant attention to social justice (Dean Nieusma 2008). In HU/SS electives for engineers, three of us (Leydens, Lucena, Schneider) developed and now teach a course on Engineering and Social Justice and implemented social justice modules in courses on Energy & Society and Communications. Yet a key challenge remains: how do we scale up these activities to other schools and programs so they do not remain isolated examples in a few courses? Might Leydens' proposed guidelines for addressing faculty resistance to teaching social justice across the curriculum be a necessary first step for widespread dissemination? If so, many readers might be wondering to what extent are these guidelines applicable everywhere and at what cost?

Leydens' seven proposed guidelines also seem to be fairly universal, applicable or at least adaptable to different types of institutions. Yet the costs of applying them will be different and perhaps significant in some places. For example, what would be the costs of unveiling the apolitical myth in different engineering programs? Many of the chapters in this book imply that engineers draw power and comfort by maintaining the apolitical myth because the myth exempts them from social responsibility while safeguarding the so called "technical" world to themselves. If that is the case, what would be the cost to engineers, and to their ESJ colleagues, of unveiling this myth? How many of us are ready to start co-teaching, co-writing, and co-researching at the boundaries between the technical and the non-technical with the goal of unveiling this myth? The partnerships of Baillie/Armstrong and Schneider/Munakata-Marr present, in this volume, exemplary collaborations of this type. Unfortunately, these often come at a cost. For example, in some places, tenure and promotion committees do not see the value of such collaborations. Many academic administrators do not encourage them as these confuse record keeping of which department gets credit for such a course.

Furthermore, Leydens invites us to reflect, research and write on three missing narratives that faculty experience when facing the challenge of social justice in their teaching: transformation, non-transformation, and "useful" resistance. Although some of us spend time sharing some of these narratives during ESJP conferences, (and perhaps during faculty reflections in our annual evaluations in our own institutions), we need a more concerted research effort to bring these out with the goal of informing, and hopefully encouraging, the next generations of ESJ scholars.

13.9 Engineering Systems and Social Injustice?

Andres Valderrama's chapter exemplifies how his engineering background, combined with his training in STS, allowed him to question and thus bring to light what many of us take for granted. That is, public engineered systems, even when endorsed and justified by the rhetoric of social justice, might end up furthering inequalities and injustices. Valderrama's analysis puts on trial the main argument by politicians, engineers and technocrats involved in the construction of the *Transmilenio*, i.e., "[It] has inverted the conventional use of urban space where the wealthiest citizens rip off the benefits of public investments in infrastructure, while the less privileged have restricted and problematic access to infrastructure." As more of us spend time working in programs aimed at educating engineers to be future systems designers, builders and operators, Valderrama's chapter should make us wonder how to instill this critical thinking about systems into our engineering students even when they do not have a background in STS. Can this kind of critical thinking education be integrated into engineering systems courses without requiring additional credits from students? For those of us who might be planning such integrations, it is important to remember Valderrama's key lessons. First, this type of analysis requires us *to pay attention to political discourse* as promulgated by proponents of the system. Second, it involves *resisting*, *or at least questioning*, *general transportation* (*or system design*) *principles*. Third, it requires *questioning how people are framed in relationship to the system*, e.g., transport owners and drivers as bad guys, the poor as the great beneficiaries, and vulnerable (disabled) citizens as threats. Critical thinking about systems based on these lessons might require that instructor(s), either one or in a team, combine engineering and STS (or social science) backgrounds.

These lessons are also clear strategies of how we can counteract the effects of an engineering mindset—uncritical acceptance of authority—which according to Riley (2008) gets in the way of engineers from seeing injustices and engaging in social justice. If we can educate our engineering students to critically question the sources of power and authority involved in the making of a system (the politician, the engineer, the technocrat, general principles, models), as Valderrama has done in his chapter, we would have gone a long way in their preparation to see injustices and embrace social justice.

13.10 Engineers and Non-governmental Organizations (NGOs)

Richard Arias' chapter is a welcomed reminder of how an increasingly recurring attitude among our engineering students—an increasing dissatisfaction with traditional career pathways available to them—can become an opportunity for their engagement in social justice if they are willing to start or join an NGO. This is clearly uncharted territory in engineering education; i.e., how to educate and prepare students to work in NGOs. Reinforced by the ideology of employability, business and economics minors have been traditionally popular among engineering students. But what would a curricular minor to help engineering students get ready for work in NGOs look like? What kinds of knowledge, skills, and attributes would engineering students need to work in NGOs?

His chapter also challenges us to map the NGOs in relationship to engineering practice and employment to see what kinds of opportunities might already be available to engineering graduates in this sector. If NGOs related to social justice have been mapped according to functional categories like Health, Education, Environment, Community/Social Welfare Services, Development, Disaster and Emergency Relief, Human Rights, Culture, International, Philanthropy/Voluntarism and Grantmaking, and Network Organizations (Ha et al. 2007), how and where do engineers fit better or can they make better contributions?

Furthermore, Arias' chapter also invites us to consider developing and instilling the capacity to create *social enterprise* among engineering students. The social entrepreneurship movement has taken hold in other corners of society and academia (Steyaert and Hjorth 2006) but not in engineering education. What would social entrepreneurship look like in engineering education? Can it be integrated in courses like senior design? How would engineering schools, traditionally geared for for-profit corporate employment, support, or even allow, social entrepreneurship activities? Or given how pervasive the ideology of for-profit employability is in undergraduate engineering education, might it make more sense to help engineers later on in their careers to migrate from corporate jobs to NGO opportunities? As more experienced and mature practicing engineers become less reliant on long-term corporate employment (Barley and Kunda 2004) they might be more ready to consider NGO employment.

13.11 Renewable Energy and Social Justice

Like Valderrama's, Nicholas Sakellariou's chapter challenges us to question assumptions behind those technologies that many of us view as technologies for the social good, e.g., public transportation, renewable energy technologies, etc. Conceptually and politically, this challenge is interesting and provocative for ESJ scholars, like the authors of this volume. Most of us are accustomed and have frameworks to question technologies with obvious connections with social injustices (e.g., technologies of war) but how are we to begin a more systematic questioning of those technologies that we tend to view as "socially just" such as renewable energy technologies? And what are the conceptual and political implications of doing so? This is clearly new and uncharted terrain for many of us.

Sakellariou also claims that "there are currently few incentives to work with communities in designing wind/solar energy infrastructures." If that is the case, how could we, as activist/scholars of ESJ, integrate community participation with social justice at the core into renewable energy engineering (REE) practices? What strategies should we use? And if successful, what would these engineering practices with communities look like? It seems that Sakellariou's plan is perhaps less problematic than those that call for a full integration of the social and the technical. His is a call for the participation of local groups resisting projects in the decision-making about the project (i.e., procedural justice) while respecting the boundaries around engineers doing "purely technical work." Finally, Sakellariou's chapter makes us wonder to what extent, if any, social justice can exist within, or co-exist alongside, the concept of corporate social responsibility (CSR) in our courses, programs and the potential employers of our students. Might ESJ, and its advocates, run the risk of being co-opted by discourses and practices of CSR? Or might there be opportunities in this co-optation? Can CSR be an entry point for ESJ into the corridors of corporate power? And if so, at what cost?

With these chapters, and the questions they elicited, as foreground, I invite the readers to now join us in a quest for teaching and researching the intersections between engineering and social justice. The potential of engineering to reshape our world and how we live is too great to be void of an explicit dimension of social justice. Let's make this dimension visible and relevant.

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