Chapter 11
Bridging Sustainable Community Development and Social Justice

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Abstract In this chapter, I briefly trace the history of engineers' involvement in development, from national to international to sustainable development, and highlight when and how "sustainability" and "community participation" became important dimensions in this history. Yet throughout this trajectory, a number of engineering mindsets have come to shape engineering practice and education and contributed to making social justice invisible to most engineers, restricting their ability to contribute to a fair distribution of rights, opportunities, and resources when working in community development and humanitarian endeavors. This chapter outlines these mindsets and proposes a number of possibilities to overcome them so engineers can effectively address social justice within their practices and projects in community development.

Keywords International development • Sustainable development • Community development • Engineering mindsets • Ideology • Critical pedagogy • Social justice

Introduction

In the last decade, there has been an amazing surge in engineering activities related to humanitarian endeavors and community development. 2011 was designated as the Year of Humanitarian Engineering in Australia by all major engineering societies in that country. In the US, two of the major engineering societies created Engineering for Change (E4C), a coalition of engineering societies interested in helping communities in need. There are now organizations similar to Engineers Without Borders (EWB) in dozens of countries around the world. This surge has been preceded by a relative recent and scarce history of engineers involvement in these kinds of activities, from engineering interventions through appropriate technology in the 1960s and 1970s to Fred Cuny's humanitarian activities that span from 1969 to 1995. While in present-day engineering education these activities

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might be very attractive for multiple reasons (e.g., recruitment/retention of students in engineering, public image and societal relevance of engineering, relevance to accreditation, hands-on student learning, and so on), they also raise important questions for all of us involved in them:

- Why has engineering as a profession been a late-comer to these activities when compared with medicine, law, and nursing, professions with a long-standing history of involvement in humanitarian endeavors?
- How has the history of engineers in national and international development shaped the contemporary assumptions and practices in humanitarian relief and/or community development?
- How have ways of thinking in engineering (engineering mindsets) and their associated practices and institutions, influenced the ways in which engineers carry out humanitarian and community development endeavors? Has this influence led engineers to emphasize certain behaviors or approaches, such as engineers' desire to help, while neglecting others, such as attention to social justice?

My thesis here is that until we fully understand the history of how engineers came to be involved with development and communities and the consequences of this history for present-day practices and projects, and appreciate the influence of the engineering mindsets on how engineers define and solve problems, it will be very difficult for engineers to achieve effective, sustainable and socially just community development.

Brazil: An Example of Engineers and National Development

Historically, I first locate engineers and their relationship to development around the creation of countries throughout the nineteenth and early twentieth century. Although engineers from different countries were involved in different projects around the world outside their homelands (e.g., surveying new lands and building canals for empires, organizing warfare), it was at this time when engineers also began to serve images of progress in their own countries (Downey 2007). Brazil presents an interesting case of a country that was first a Portuguese colony, then an Empire of its own, and finally a sovereign nation-state. Throughout this transformation, engineers were challenged with the construction of a country, first, to serve the interests of the Portuguese empire and finally guided by an image of national progress: Ordem e Progresso (Lucena 2009).

Before this image took hold in early twentieth century, engineers during the Brazilian Empire (1822–1889) mapped the country and its natural resources and organized and carried out military activities for the imperial crown. During the Republic (after 1889), supported by strong state governments, regional engineers built regional infrastructures and engineering schools to support an agriculture-based economy in need of replacing free labor after the abolition of slavery in 1888. A handful of military engineers, known as The Positivists, first proposed "Ordem e

Progresso" (Order and Progress) as a national motto written in the Brazilian flag, and built and expanded communication networks (telegraph, roads, river navigation system) to promote the idea of one Brazil (Diacon 2004). Yet this image of national progress did not take hold immediately as strong regional interests dominated Brazilian politics and economy until the 1920s. It took for the government of President Getulio Vargas in 1917, and the re-writing of the constitution creating a "new State" (Estado Nuovo) to define *Order* as that achieved by a powerful centralized state and *Progress* as national industrial development in the form of import substitution mixed with Taylorism and Fordism (Williams 2001). Brazilian engineers joined these efforts at the federal and state levels and built national oil and steel works as cornerstones of a national industry and infrastructure that would make Brazil an economic power in Latin America. Once the image of Order and Progress became dominant, engineers built Brasilia as the country's administrative and political capital and made Brazil into an auto-manufacturing giant in the 1950s (Alexander 1991). During the military regimes of the 1960s and 1970s, which elevated the image of Order and Progress to new heights, engineers built the Itaipu hydroelectric (the largest in the world until the construction of the Three Gorges Dam), nuclear energy plants, and Embraer, Latin America's first and only aircraft manufacturer (Adler 1987).

Engineers and the Making of Nations

In Brazil, as in many other countries, during the period of national development, governments tried to incorporate dispersed and culturally different communities and groups of immigrants into a larger national whole. As political scientists and sociologists have shown us, this incorporation – the making of a nation – happened mainly through educational and cultural institutions and agencies that controlled and supervised aboriginal and immigrant populations (Anderson 1991). But this project of nation-making also had significant physical and material dimensions that required many engineers to be involved either as builders of physical infrastructure or as public officials in charge of institutions. For example, right after the birth of the Brazilian Republic (1889) military engineers, like Candido Rondon da Silva, following orders to build a national telegraph network, tried to make Amazon natives into national subjects as they laid out the network (Diacon 2004). In early twentieth century Mexico, under the administration of Porfirio Diaz, influential Mexican engineers involved in the ministry of public education (Secretaria de Education Publica) tried to construct "Mexican citizens" out of indigenous populations through a centralized form of education (prepa) aimed at creating Mexicans out of the dispersed ethnic communities that composed the population (Lucena 2007). In late nineteenth century US, engineers were involved in the organization and improvement of urban and industrial infrastructure as immigrant groups from Europe went to the US to supply labor for industry (Britton 2001). Engineers involved in the organization of engineering schools or systems building were contributing not only by bringing a specific service, like electricity, to people but also by integrating them into a national whole.

In these episodes of national development, ideas of national progress, often promulgated by political elites and carried out by engineers, prevailed over any kind of community development or humanitarian endeavors. Even when engineers tried to enact notions of social justice, as when US progressive engineers cared about smoke pollution experienced by city dwellers and improved the efficiency of coal burners, they were involved in nation building. How might these involvements in *national development*, that continue to this day, influence, and perhaps shape, engineers' views of communities and ways of working with them? How can engineers participate in both national development (and its associated industries, infrastructure, institutions) and in working for social justice?

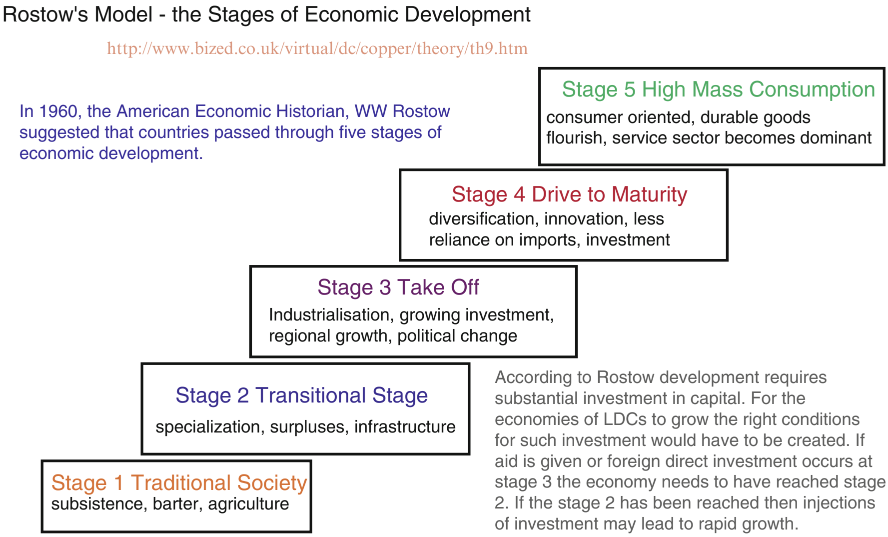
Engineers and International Development

The end of World War II, and more precisely US president Truman's Point IV of his second inauguration speech, launched the era of international development (Rist 2004). In addition to national development, engineers from the US and USSR, the two sides that defined the Cold War, were challenged with an image of progress that went beyond their national borders. The new challenge called for nation building outside one's national boundaries to be done mainly though financing, science, engineering and technology. As President Truman put it,

> we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of *underdeveloped* areas. More than half the people of the world are living in conditions approaching misery. Their food is inadequate. They are victims of disease. Their economic life is primitive and stagnant. Their poverty is a handicap and a threat both to them and to more prosperous areas. For the first time in history, humanity possesses the knowledge and skill to relieve suffering of these people. The United States is pre-eminent among nations in the development of industrial and scientific techniques. The material resources which we can afford to use for assistance of other peoples are limited. But our imponderable resources in technical knowledge are constantly growing and are inexhaustible. (President Harry Truman, Second Inauguration, Jan 20, 1949 quoted in (Rist 2004))

Out of this vision, powerful institutions of international development emerged such as World Bank, International Monetary Fund (IMF), Inter-American Development Bank (IDB), US Agency for International Development (USAID), and the Peace Corps. All of these either employed engineers or funded engineering projects in private companies contracted to carry out development projects.

The dominant economic model that informed the policies and programs of international development, at least for those countries not behind the Iron Curtain, was that of Walt Whitman Rostow, leading US economist and subsequently advisor for Presidents Kennedy and Johnson.



In this model, traditional societies move from transitional and take-off stages to maturity (high mass consumption) through specific economic and industrial policies and infrastructure development. Along the way traditional communities (aboriginal, ethnic, rural) and their traditional ways of life and production, are viewed as barriers to economic growth, industrialization and mass consumption (Rostow 1990). Hence, followers of this model, including those engineers who made careers in international development, were challenged to transform traditional communities and put them on a path towards modernization. In the process, communities were convinced, and often forced as when their villages stood on the path of a hydroelectric project, to abandon their means of sustenance in exchange for efficient techniques of extraction and production so they could contribute to economic growth, participate in mass consumption and be part of national development (Scott 1998).

Although there are some exceptions in the golden decades of international development (1960s–1970s),[1] most engineers involved in international development followed Rostow's model and its assumptions about communities. These engineers viewed communities as impediments to modernization and defined them in terms of what they lacked such as efficient infrastructure and manufacturing, innovation, industry, etc. (Ekbladh 2009). So in addition to the influences of working in national development, how might working in *international development* have influenced,

[1] There are a number of very engaging case studies of engineers who have challenged the ideology of development. For example, Fred Cuny questioned models of development (in the form of humanitarian aid), reconceptualizing "victims" of humanitarian crises into "partners" who needed to be employed in the solution of their own problems (Cuny 1983). Another example is that of the Volunteers in Technical Assistance (VITA) engineers who questioned international development as an instrument of Cold War politics in the 1960s and implemented an alternative model to provide technical solutions to the developing world (Wisnioski 2012).

and shaped, engineers' views of communities and ways of working with them? How might present-day desires to "help the needy" be rooted in historical commitments to modernize those who are "backward"?

Engineers and Sustainable Development

The emergence of the concept "sustainable development" has been attributed to the Brundtland report (WCED 1987) and to its subsequent acceptance and institutionalization that took place after the Rio Conference in 1992. Interestingly, Brundtland's became the dominant definition of sustainable development, accepted and adopted by most engineering organizations who wanted to promote it.[2] Perhaps this was a good faith effort to question and remedy the perils of big development and economic growth in which large numbers of engineers have been involved. Unfortunately, the adoption of this definition reinforces relationships of power and domination between countries in the global north and south and between experts and lay people. Elaborating further on why definitions of sustainable development serve the interests of experts, including those of engineers, Jeffrey Bridger and A.E. Luloff argue that

> those who depict sustainability on a macro scale portray environmental problems in such apocalyptic terms that they sometimes revert to the language of technocratic planning and administration and speak of the need for global ecological planners in international agencies who must work with national political elites and multinational corporate leaders to manage these environmental crises… The problem with this kind of solution is that relations of domination are left in place. Those who control the resources and who are responsible for many of the decisions and actions that have caused insidious environmental damage are generally charged with cleaning up their mess… The result is a crisis mentality which relies on technological solutions for much larger structural problems. (Bridger and Luloff 1999)

This reliance on technological fixes clearly appeals to engineers, especially if proposed solutions are accompanied by substantial funding from international agencies, national governments, and private corporations which have made sustainable development a key business strategy. Yet these technological solutions might not necessarily lead to sustainable *community* development since the practices that support communities reside at the local level. Bridger and Luloff propose that

> [b]y shifting the focus on sustainability to the local level, changes are seen and felt in a much more immediate manner. Besides, discussions of a 'sustainable society' or a 'sustainable world' are meaningless to most people since they require levels of abstraction that are not relevant in daily life. The locality, by contrast, is the level of social organization where the consequences of environmental degradation are most keenly felt and where successful intervention is most noticeable…sustainable community development may ultimately be

[2] A search for definitions of "sustainable development" within engineering societies will reveal a striking acceptance of Brundtland's definition without much consideration of what it means for engineering education and practice.

> the most effective means of demonstrating the possibility that sustainability can be achieved on a broader scale, precisely because it places the concept of sustainability in a context within which it may be validated as a process. By moving to the local level, the odds of generating concrete examples of sustainable development are increased. As these successes become a tangible aspect of daily life, the concept of sustainability will acquire the widespread legitimacy and acceptance that has thus far proved elusive. (Ibid)

In sum, although well intentioned, the adoption of sustainable development by organizations that employ and represent engineers has reinforced the status quo by maintaining relationships of power (e.g., North vs. South; rich vs. poor; expert vs. lay) while neglecting how sustainable practices affect local communities, and in particular how these practices might actually reinforce inequalities and social injustices.

Engineers and Communities?

Up to this point, through their involvements in national, international and sustainable development, engineers learned to view communities as groups of people to be integrated into national wholes, or as impediments to economic growth and modernization of the economy, or as lacking and in need of aid, or as entities that are invisible to technocratic definitions of sustainable development. With very few exceptions throughout this history of development like Fred Cuny (see footnote 1), up to this point engineers have engaged communities predominately through the "deficiency lens," i.e., in terms of what they lack or how they are "burdens" to higher goals like national development. For a more detailed analysis of the meanings and views of communities see (Lucena et al. 2010).

Some concerned engineers responded to this mistreatment of communities through Participatory Community Development (PCD). PCD entered development practices in late 1980s, ironically known as "the lost decade of development" with books and processes like *Listen to the People* (Salmen 1987) or *Putting People First* (Cernea 1985). These authors proclaimed more than 20 years ago certain truisms that we now take for granted in community development. For example, Cernea claimed that the role of the social analyst is to "identify, conceptualize, and deal with the social and cultural variables' that make up this missing [social] dimension [in development projects]. Even if the financial aspects of a project are apparently proceeding smoothly, these sociocultural factors 'continue to work under the surface. If the social variables remain unaddressed or mishandled, then the project will be unsustainable and fail, no matter which government or international agency promotes it." Continuing, Cernea argues that the "beneficiaries of development should have a say in implementation, and sees social scientists as playing the central role in granting this voice…putting people first is held to be 'a reversal because it proposes another starting point in the planning and design of projects than that taken by current technology-centered approaches'" (Cernea quoted in (Francis 2001).

Not many engineers involved in development practices would argue with that. Yet, although a detailed review of the critique of participatory methods is outside the scope of this chapter, it is worth noting that participatory methods have not necessarily resulted in benefits for the intended beneficiaries: communities.[3] Engineers committed to sustainable community development should be aware of these potential problems:

- *The tyranny of decision-making and control*. Participatory facilitators often override existing legitimate decision-making processes. For our purposes, we should be considering whether and how engineers filled with good intentions, the latest participatory techniques and even a strong commitment to sustainability, might be marginalizing communal decision-making processes already in place.[4]
- *The tyranny of the group*. Group dynamics put in place by participatory methods (e.g., a community meeting) might lead to participatory decisions that reinforce the interests of the already powerful (e.g., community leaders who control community resources and might end up controlling the outcome of meetings). For our purposes, we should question if engineers' interactions with others in community development projects might be reinforcing the interests of the powerful.[5]
- *The tyranny of the method*. Participatory methods like those listed above might silence or exclude others that have advantages participatory methods cannot provide. For example, participatory methods introduced in Bali, Indonesia, ignored a traditional governance system located in Buddhist temples with dire consequences for water distribution and sustainable farming (Ramaswami et al. 2007)

Being mindful of the limitations of these methods, engineers can shift decision-making power towards communities, and especially towards their more marginalized members, when working in community development. In sum, throughout the history of engineers and development a chasm between development and the interests of communities has persisted, even after the inclusion of participatory practices. Development was first about the development of nation-states, then about the geopolitics of the Cold War and economic modernization, and more recently to secure economic growth within ecological limits. Engineers have actively, and in many cases successfully, participated in each one of these stages of development. So given this history how might we put the interests of local communities at the center?

[3] For comprehensive analyses and critiques of participatory methods, see Cooke and Kothari (2001).

[4] See Lucena et al. (2010, Chap. 4) for the case study "The Stranger's Eyes" as an example of how this tyranny was enacted in a development project to install mills for grinding grain in various villages in Mali.

[5] See Mosse (2001) for a detailed analysis of how this happened in a participatory farming systems development project in India.

Engineering Mindsets: How Ideology Makes Social Justice Invisible to Engineers

Bridger and Lulloff's view of sustainable development challenges engineers to include the following dimensions in order to benefit communities through their practices and projects:

- Local economic diversity
- Self-reliance; local political control
- Reduction in use of energy; recycling materials
- Enhance biodiversity of local ecosystem; careful stewardship of local natural resources
- Social justice

If we take social justice to be the fair distribution of rights, opportunities, resources while minimizing risks and harms among members of a particular community, we can see that even the first four dimensions have significant elements of social justice. For example, local economic diversity challenges engineers to consider the economic relationships that exist and will be created between community and external markets prior to and after their intervention. By enhancing local economic diversity, engineering projects can serve to strengthen local market activity, generating new market opportunities and increasing revenues for community members, while disentangling local economies from external markets that might be detrimental to communities. Self-reliance/local political control challenges engineers to think about the political relationships that exist and will be created (or transformed) in a community prior to and after their technological intervention. By promoting local political control, engineering projects can enhance the political rights of community members while minimizing political control from governments or decision makers far away. Reduction in energy use, recycling materials, enhancing biodiversity and careful stewardship of natural resources challenge engineers to think about how their projects will impact the availability of valuable local resources (energy, materials, natural resources) and affect ecological relationships between community and its ecosystem.[6]

But providing an enhanced definition of sustainable development, and its constitutive dimensions grounded on social justice, is not enough if engineers, blinded by the assumptions made throughout their history in development, are not ready to see and embrace these. Besides the historical and structural constraints placed on engineers by the ways in which they have been involved in development, what else might have contributed (and continues to contribute) to engineers' difficulties in seeing and engaging in these dimensions, especially social justice?

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[6] For example, engineers working with Bridges to Prosperity (B2P) build pedestrian bridges with communities that allow its members to buy and sell produce in places they could not before (local economic diversity), attend community meetings and reach voting polling places (local political control), reduce the use of fossil fuels and (re)use local materials to construct the bridges.

Engineering mindsets, as described by Donna Riley (2008), are characteristics of engineering education and practice that have evolved and come to define where and how most engineers work, think and approach problem definition and solution, and, in short, what they value. These mindsets are:

- Dominance of military and corporate organizations
- Positivism and myth of objectivity
- Desire to help and persistence to do it
- Narrow technical focus
- Uncritical acceptance of authority

According to Riley, these mindsets create significant blind spots to engineers' abilities to see social injustices and actively participate in projects and practices conducive to social justice. How might these engineering mindsets get in the way of engineers seeing social justice?

Dominance of military and corporate organizations This is very evident in most engineering schools from the job fairs, career pathways of most graduates, places of work, training and/or funding of engineering faculty, sources of funding for engineering labs and facilities, etc. Through socialization in engineering schools, which takes place via stories from professors in the classrooms, internships, company-sponsored events, etc., students learn to accept as natural the presence, dominance and hierarchies of power and decision-making within these organizations. Most students never question the power and influence that these organizations play over the organization of academic life all around them, e.g., which buildings get built, who enjoys the privileges of endowed positions, who sits at universities' board of trustees, etc. Students are also socialized into ways of decision-making and communication that might be antithetical with democratic consensus building and participatory decision-making in community endeavors. For example, after studying in depth what oil extraction has done to communities and natural environments around the world (Maass 2009), I presented students with a contrasting quote from fellow engineer and former CEO of Exxon-Mobil Lee Raymond who said: "we [oil co's] have a tremendous opportunity and a responsibility to improve the quality of life the world over. Virtually nothing is made without our energy and our products…we condemn the violation of human rights in any form, and believe our stand on human rights sets a positive example for countries where we operate." (quoted in Ibid, p. 119). Most students took for granted Raymond's condemnation and accepted the authority of his perspective –after all he is a fellow engineer in charge of the most powerful corporation in the world- in spite of the overwhelming evidence they studied before. Students were not bothered how Raymond's unsupported perspective might be silencing, at least in their head, all others that questioned the human rights record of the oil companies.

Uncritical acceptance of authority As seen in the example above, the dominance of corporations and military organizations influences how engineers accept the authority that comes from these sources. But there are other complex reasons for engineers' acceptance of authority. For example, in the US, there is a very visible political and social conservatism among engineers who uncritically accept the authority of the gospel, law, and numbers and rarely question assumptions, interpretations and power dimensions behind these.[7] More importantly perhaps is how engineering students learn to accept the authority of engineering problem solving (EPS), the core method that serves as the foundation for homeworks and exams in most engineering courses, and what this acceptance does to their ability to accept alternative perspectives and respect dissent. As Gary Downey and I reported elsewhere,

> students who complete hundreds of problem sets on graded homeworks and exams are simultaneously receiving intensive training in dividing the world of problem solvers into two parts, those who draw boundaries around problems appropriately and those who do not. The first group becomes capable of being "right," while the second, by implication, may become "wrong." One consequence is that some students emerge from engineering curricula knowing that engineering problems have either right or wrong answers, that the chief metric of ability is the frequency one is right, and that difference may be an indicator or error. In the process, such students have acquired solid grounds, seemingly mathematical grounds, not to trust the perspectives of co-workers who define problems differently. In other words, learning the five-step engineering method [EPS] can make a diversity of viewpoints suspect by definition. (Downey and Lucena 2007)

If learning EPS conditions students to reject solutions proposed by those who do not master EPS and solve problems like them, then uncritical acceptance of EPS into their lives makes them unlikely candidates to embrace social justice.

Positivism and myth of objectivity The origins and persistence of this engineering mindset are complex and varied and have different roots in different countries. For example, Ken Alder has shown how engineers of the French Revolution called for optimization of projectile trajectories over aesthetic preferences by the King to have especial decorations on cannons. Challenging royal authority, engineers tried to establish an empirically based relationship between trajectory and cannon length and thickness (Alder 1997). The history of engineering is filled with episodes where for different reasons (e.g., desire for status, access to money, boundary work vs. scientists, need for theoretical development, etc.) engineers have resorted to positive knowledge and instrumentation as main sources of knowledge (Seely 1991; Vincenti 1993; Barley and Orr 1997). This mindset has been reinforced in engineering curricula by a number of factors, including the emphasis and higher status enjoyed by math and science in academia. In her book, Riley shows the preponderance of this mindset through a series of jokes that illuminate how engineers tend to privilege positive knowledge, ("If it cannot be measured it does not exist"), and certain legitimate sources of that knowledge (e.g., instruments assumed to be void of any subjectivity).

Positive knowledge can be a powerful tool for the goals of social justice by measuring poverty, infant malnutrition, illiteracy, etc. and making them real in the minds of empiricists (Brighouse and Robeyns 2010). Yet often commitment to social justice leads us to act in spite of the absence of data, driven by principle and values.

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[7] Interestingly with the exception of Chris Toumey who has researched the conservative and religious views of scientists (Toumey 1994), there is almost no research on conservative attitudes of engineers since the 1970s (Ladd and Lipset 1972).

In many parts of the world, there is absence of data related to the conditions of marginalized groups; their lack of political and economic power often renders them invisible to the government agencies in charge of collecting demographic data on public services or health (e.g., HIV rates among homeless). So they are not being measured but they, and their conditions, DO exist.

Also as countless STS case studies have shown, we also need to learn to accept the subjectivity in measurement tools and instrumentation (Latour 1987; Latour and Woolgar 1986). Who builds them, how they are used and calibrated, how the data is obtained, how it is interpreted orally and in writing, and how it is read by the many audiences, all of these introduce human subjectivity in every step of the acquisition of positive knowledge. So blind commitment to this mindset leads engineers not to see those injustices that cannot be empirically measured or to ignore the subjectivities involved in measuring.

Narrow technical focus Donna Riley introduces us to this mindset through a popular joke about an engineer who is about to be decapitated in a guillotine yet, instead of questioning whether justice is being served through his own execution or even showing anguish or desperation as he is about to lose his life, he is rejoicing at the opportunity to help the executioner how to figure out a technical malfunction. In *The Existential Pleasures of Engineering*, Samuel Florman provides us with a philosophical justification for this technical focus when he writes "the engineer's first instinctive feeling about the machine is likely to be a flush of pride…After the engineer's initial burst of pride has run its course, quite a different sentiment reveals itself—his love of the machine for its intrinsic beauty." (Florman 1996, p. 132). Pride and love for and aesthetic enjoyment of machines, especially if we built them, are important dimensions of our human condition as *homo fabers*. When we build these with our hands, we often come to appreciate the physical exertion required, the kinds of materials and energy involved, and how others with more dexterity and experience (often mechanics and technicians) solved problems that emerged along the way (Crawford 2009). The problem is that *making with the hands* has been almost eliminated from engineering education[8] to make room for more scientific curricula and textbook and computer mathematical idealizations of machines or physical contrivances. Graded homework, exams and labs reinforce the notion that what matters is the narrowly defined, properly bounded mathematical idealization of a physical reality void of all connections with the social world, including manual labor (see Chapter 12 by Rolston and Cox in this volume for a full analysis of the mental vs. manual divide in engineering).

At the same time, overemphasis on the technical leads engineers to ignore or undervalue the social dimensions of their work. Although ABET 2000 criteria and the *Engineer of 2020* report challenge engineering education to seriously consider the non-technical dimensions of engineering work, we are still waiting to see these

[8] Perhaps with the few exceptions of little manual work that happens in design projects and this manual work is often given to the machinist on campus. There is very little of the grade, if any, at stake for manual work.

dimensions valued in most engineering curricula. Most engineering faculty continue to significantly value mathematical idealizations of the technical over the non-technical. This valuation is reflected in curricular practices such as when the social and ethical elements of senior design projects are worth only a minimal part % of the grade in humanitarian engineering projects, clearly signaling to students not to take these seriously (Leydens and Lucena 2009). Engineering students also tend to place highest value on technical courses over non-technical ones and often wonder why they have to work hard for liberal arts classes which, according to them, do not deserve the same effort as their technical classes. So a narrow technical focus divorces students from their physical connection to making things and from the social dimensions of engineering.

Desire to help and persistence to do it As we have written elsewhere, there is a recent surge of engineering activities aimed at helping those in need around the world (Schneider et al. 2009). Historically, in the US this desire has been in tension, and often in direct conflict, with engineers' loyalty to corporate and military bottom lines (Wisnioski 2012). As mentioned above, there have been few instances when engineers have acted out of commitment to enhance the quality of life of the poor, immigrants workers, or communities in the developing world. In addition, many engineers, acting more as concerned citizens or encouraged by management in order to improve productivity, find ways to help outside of their work, in community organizations, churches, and civic projects (Geroy et al. 2000). Yet as a profession, engineering has a very recent history in dedicating and organizing educational and professional activities towards helping, especially when compared with law, nursing, and medicine (Mitcham et al. 2005). The recent emergence of organizations like Engineers Without Borders or Engineers for a Sustainable World reveal a heightened desire to help by engineers involving significant numbers of students, faculty and professionals and likely due to three historical events. First, the end of long-term loyalty between corporations and engineers has made it clear to engineers that they can no longer assume that they will have long-lasting careers with corporation. This dislocation of employer-employee loyalty has led many engineers to become freelance agents, "itinerant experts in a knowledge economy" (Barley and Kunda 2004) or individual consultants. These transformations, in addition to increasing dissatisfaction in the workplace due to budget reductions and technical work moving elsewhere, have led many engineers to seek a purpose for their work in development work or community service. But this desire to help has been motivated not by what is best for communities but by seeking a sense of purpose in one's work difficult to be found inside corporations.

Given how the history of engineers in development has shaped the way in which engineers engage communities, and the blind spots created by the engineering mindsets, social justice continues to be a missing dimension in engineering education and practice, including in many activities related to sustainable development.[9] So how might we rescue social justice and incorporate it into engineering for development so that it truly becomes engineering for *sustainable community development* (SCD)?

Can Critical Engineering Education Counteract the Blinders of History and Ideology?

Perhaps we can teach students to see, reflect and critically question these engineering mindsets so they do not take these for granted nor assume that this is the way the world of engineering has always been and will always be. Here are some strategies.

Counteracting the dominance of military and corporate organizations Teaching students different forms of organizational disobedience might challenge the dominance of military and corporate goals. For example, using the example of engineers from Volunteers in Technical Assistance (VITA), students learn how engineers *inside* the military-industrial-academic complex, who wanted to develop technologies for poor communities around the world, found a way to do so within corporations and universities. Committed to helping those who had no access or resources to the expensive lab testing and prototype development and wanting to remain distant from Cold War politics, VITA engineers found creative ways to use research labs, such as those found inside General Electric, to provide technical solutions to the questions that they were getting from poor communities (Wisnioski 2012).[10]

Students can also learn about whistle blowing, its costs and benefits, as a form organizational disobedience. For example, Roger Boisjoly, perhaps the most famous engineer-whistleblower in recent US history for disclosing the failure in decision-making prior to the Challenger disaster, visited our campus and shared with students the costs (e.g., no aerospace company will hire him again) and opportunities (e.g., he created his own firm for forensic engineering) incurred by his actions.[11]

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[9] Note that these generalizations are drawn mainly from the history and organization of US engineering education and practice. It could be interesting to see if these apply in other national contexts, particularly in those who have emulated US educational and professional practices vs. those which are very different from the US. Also I am aware of the important exceptions from which much can be learned, e.g., US Progressive engineers in early nineteenth century, VITA, Fred Cuny, Mexican engineers of the Revolution, and present-day organizations like EWB-Australia and ISF-Colombia.

[10] Matt Wisnioski also documents other ways in which engineers have challenged the dominance of corporate and military organizations, for example, by creating *Spark*, an underground journal where they questioned and critiqued their corporate employers profit motives during Cold war weapon development.

[11] Brian Martin's *The whistleblower's handbook: how to be an effective resister* provides an excellent account of the mistakes, consequences and strategies that engineers face when speaking out against wrongdoing in a corporate setting. Also see Martin and Rifkin (2004).

We can also teach students about opportunities for humanitarian and community development engineering within the armed forces as a way to challenge the dominance of military organizations. For example, one of my engineering students and US Air Force (USAF) officer chose to revise the humanitarian operations manual of the USAF to incorporate key dimensions of community development, including social justice. Similarly, other USAF officers are researching how to use the Air Force to conduct humanitarian assistance in a hostile environment (Pavich 2004).

Students can also learn about engineers who have given up corporate/military careers in lieu of NGOs or humanitarian careers. For example, Fred Cuny, who gave up a traditional engineering career to focus on humanitarian relief efforts, serves as an exemplar to challenge conventional engineering career trajectories.[12] Or students can learn how to distinguish differences among organizations such as profit oriented, customer oriented, and engineering oriented (Harris et al. 2009, Chap. 8) and assess the companies where they want to work by asking critical questions like, does customer satisfaction go beyond prompt delivery of goods and services within budget to include public safety, accountability, transparency and relationships with the community? Is the company mainly interested in short term return to shareholders? Or does it care as well about customers' well-being, and in supporting engineers' autonomy and commitment to their professional codes of ethics?

Questioning the uncritical acceptance of authority Engineers often work and learn in organizations with rigid lines of authority so they seldom question organizational authority. In my class, students learn about the extreme consequences of engineers' acceptance of authority without critical reflection on their actions. They learn about Nazi engineers (Katz 2006; Taylor 2010) and the Engineers of Jihad (Gambetta and Hertog 2007) as extreme examples of engineers who, although very competent in their technical knowledge and skills, did not question the authority of the regimes for which they worked. Although those extreme examples are unlikely to be replicated in US settings, students also see the consequences of not questioning corporate authority as when engineers remained silent or conceded to authority in the Ford Pinto or space shuttle Challenger disasters.

Even within democratic societies, where and how might engineering students be socialized to accept authority uncritically? I often challenge students to question the authority of engineering problem solving (EPS) and its seven steps:

- Given
- Find
- Draw free-body diagram
- Identify scientific principles that apply
- Make assumptions
- Use math to solve equations, and
- Provide one solution for which they will be rewarded or punished.

[12] Other exemplars include Elena Rojas, a civil engineer who left a career in public works engineering to work with an NGO to develop community-based solutions for water supply and sanitation (Lucena et al. 2010). See also the story of William LeMessurier, who served as design and construction consultant on the innovative Citicorp headquarters tower, at onlineethics.org

After realizing the dominance of EPS in their curriculum,[13] students are invited to question, for example, who frames these problems? For what purposes? Under what kinds of assumptions? Who benefits and who doesn't when problems are pre-defined in this way and when problems are solved in this manner? After this questioning, I challenge students to redefine problems by

- *Providing their own given statements* related to a social justice issue important to them (e.g., "Given a −10 °F night temperature, a 1,500 calorie daily intake, and a 0.5 in thick coat worn by a homeless person, find the insulation material that will keep this person's body temperature to 97 °F throughout the night?");
- *Finding additional answers worth considering* (e.g., "what % of my privileged diet do I have to give up to increase the homeless person's daily calorie intake to 3,000?");
- *Drawing a relational Free Body Diagram* showing social connections to understand that this problem does not exist in isolation (e.g., network map showing homeless person in relation to shelters, food banks, police stations, available jobs, privileged neighborhoods, urban gardens, etc.);
- *Identifying alternative sources of knowledge* that might be relevant in the solution of the problem at hand (e.g., social policy, urban planning, nutrition science, distributive economics)
- *Making assumptions but critically question them* (e.g., "assuming this is a 30 year old black man… but wait, how many white males are homeless in my area? how many females? how many children?")
- Continuing to use *math* to solve the equations; and
- Providing a *number of plausible solutions* based on engineering analysis alone or engineering in combination with other sources of knowledge (e.g., "Thinsulate will keep this person's temp at 97 °F" vs. "Thinsulate + increase funding for homeless shelters + more equal distribution of food in my community…")

In sum, EPS, as the dominant method for problem solving found in most engineering science curricula, could be critically questioned and appropriated to include social justice goals.[14]

Challenging positivism and objectivity One way to teach engineering students about the myth of objectivity is to show them that engineering has always been for someone or for something. The history of engineering in different countries shows, for example, how engineers are challenged by images of progress that take different institutional, governmental, ideological, and educational forms in different places

[13] Students calculate the number of problems that they have to solve throughout their 4–5 years of engineering studies. Depending on the discipline and assumptions made during the calculations, my students have found that they solve anywhere between 1,500 and 3,000 problems using EPS.

[14] I found inspiration to appropriate EPS in the work of my colleagues in the Engineering, Social Justice and Peace (ESJP) Network such as Katy Haralampides who teaches Statistics to engineers at University of New Brunswick and Donna Riley who wrote a companion book for Thermodynamics (Riley 2011).

(Downey 2007; Lucena 2007, 2009) Engineers often respond to these challenges by building a material world (infrastructure, factories, systems, etc.) or by serving the State by rationalizing the economy or managing ministries and government agencies. Throughout these histories even those engineers deeply committed to Positivism, like the Saint-Simones in Egypt (Regnier and Abdelnour 1989) or the Positivists in Brazil (Diacon 2004), and who claimed commitment to empirical sciences as the ultimate source of knowledge, were working for someone or something and this relationship shaped the ways in which they defined and solved technical problems. Unlike EPS-type problems in engineering textbooks, engineering problems in life are always embedded in political, social, cultural and economic contexts.

In class, we study case studies showing how two groups of engineers with similar technical backgrounds and experiences can significantly disagree even when looking at the same data. This different interpretation and use of data is rooted in engineers' institutional location (from the schools where they were educated to the places where they work), way of valuing different sources of empirical knowledge (e.g., data coming from a dynamometer in a lab vs. data coming from road tests), and their ultimate goals and desires. We study the case studies of engineers' disagreement on what constituted "success" in the use of Patriot missiles in the Iraq war or what were "acceptable" launching conditions prior to Challenger explosion (Collins and Pinch 2002).

Questioning engineers' desire to help I began to question engineers' desire to help when Gustavo Esteva, a community activist from Chiapas, Mexico, came to my class and told my students: "do not go to Mexico to help. Go to listen and learn. Go to find out if the struggles of the people of Chiapas are your struggles. If so, then and only then, we can sit and talk about how we can work together." These words invited my students to question their desire to help by challenging them, first, to listen and learn and, second, to acknowledge that perhaps their desire to help is rooted in different motives far removed from the struggles of the people that they are hoping to help. Some of my students found out, for example, that seeking salvation by trying to spread the Christian faith through good works is far removed from the Zapatistas' struggle to reclaim ancestral lands or to be recognized as an autonomous community by the Mexican government.

In the US, the institutionalization of this desire to help can be traced to President Truman's Point IV about using science and technology "to relieve suffering of these people" and the emerging international development organizations and projects that employed many engineers. The origins of this desire are important for they help us understand significant discrepancies between engineers' desires and community's goals. The realization of these discrepancies, and their potential consequences for development projects, lead us to develop a list of questions for students to consider before they begin community development projects (Lucena et al. 2010):

- What are your motivations?
- What is the history and context for development in your area?

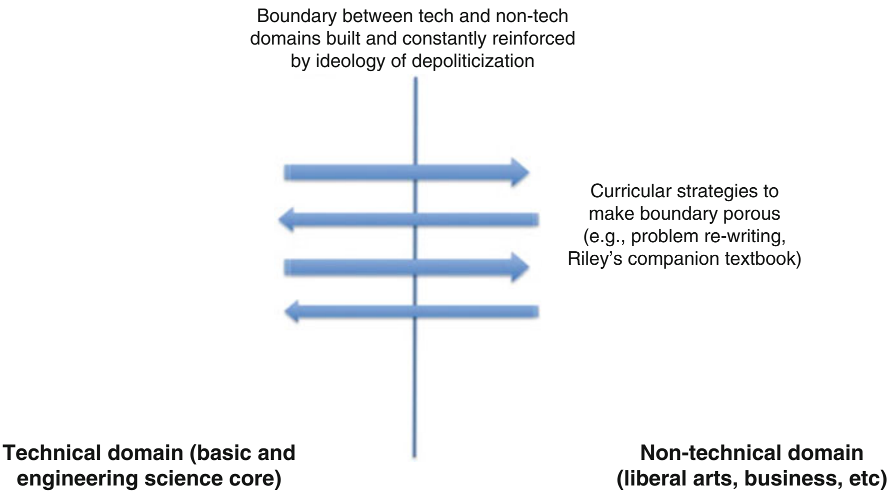
- Who benefits and who suffers from the project?
- Who is held accountable during and after your project?
- What are the possible unintended consequences of your project?
- Do you view communities as being "less than" you or your community? If so, why?

Broadening engineers' narrow technical focus The history of US engineering education is filled with attempts to broaden the education of engineers, from the early debates of the US Society for the Promotion of Engineering Education about the need for liberal education in engineering (Downey 2007) to the now regularly cited *Engineer of 2020* report (Johnston et al. 1988; Reynolds and Seely 1993; Seely 2005). Innovative programmatic developments have emerged recently, designed to counteract the narrow technical focus of engineering education in favor of more holistic and integrated approaches to engineering and its connections with domains like management, policy, STS, innovation and design such as those programs at Olin College, Lafayette College, University of Virginia, and Rensselaer. While we must applaud and continue to support these efforts, a key issue persists in most programs, including those with high percentage of courses in non-technical subjects: the pervasiveness of what Erin Cech has called *the depoliticization of engineering* (see Chapter 10 by Erin Cech and Heidi Sherick in this volume). This is the set of beliefs and practices that continue to split the world in a technical domain separate from a non-technical domain, positioning engineers as the supreme experts of the former while, in many cases, exempting them from responsibility about what happens in the latter. In engineering education, this depoliticization maintains key curricular spaces (usually the basic and engineering sciences core) well isolated from non-technical subjects, valuing the former over the latter and challenging students to be narrowly technical and serious in the core while being casual about their non-technical curriculum. As Cech writes "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" (Cech 2013).

While we want to respect our engineering peers' areas of expertise, we also want to constructively challenge them (and their students) to connect these technical areas to social justice, as Donna Riley has done through her companion book for Thermodynamics or as proposed above by rewriting EPS-based problems to include social justice. Through collaborative faculty workshops, we can explore ways to incorporate re-written problems into engineering science courses, engage students in problem redefinition and writing (hence enhancing their problem definition skills, underdeveloped in a curriculum that favors pre-defined problems), or make this activity for extra-credit by allowing student organizations like EWB rewrite problems based on their community development projects.[15]

[15] For example, EWB students in my school participate in the actual design and building of Bridges to Prosperity (B2P) for communities in the global south. I often challenge them to write

At the same time, we need to collaborate with faculty in the humanities and social sciences to open spaces in their non-technical classes for engineering students to experiment with problem re-definition. In an social science class, for example, we might allow students to bring their seemingly technical bridge project and re-write it in a way to include issues of economic exchange, migration, governance, etc. and how these affect social justice in a given locality.



In sum, we want to create and implement strategies that challenge the boundary between the technical and non-technical domains of the engineering curriculum in order to counteract one of the most pervasive and powerful ideologies –depoliticization – that gets in the way of engineers' engaging on social justice.

Conclusion

This chapter presents a road map for engineering educators and students to question the legacy of the history of engineers in development and engineering mindsets as blinders for social justice. These blinders have made social justice a marginal concern, at best, or totally irrelevant in engineering practice and education. By removing them, my hope is that future generations of engineers will not only see the importance of social justice but will place it at the center of engineering practices in sustainable development in order to achieve *sustainable community development*.

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engineering problems where they have to calculate stresses and loads on different parts of the bridge while considering how these bridges might contribute to local economic diversity, political self-determination, and social justice. Through faculty workshops I can (hopefully) establish collaborations with Statics faculty who can incorporate these problems into their courses.

While counteracting the effects of history and ideology can be daunting, especially within institutions that have been organized by these effects, my hope is that as engineering practitioners and educators we can challenge students and ourselves to

1. Appreciate the history of engineers in development, be critical of their effects and understand that they can be agents of change. Students cannot change the past but can become aware of how the past has, and continues to, shape the present and future.
2. Question models of development such as Rostow's path to modernization. But it is not enough for them to question development in the abstract. They need to see specific examples of how the ideology of development (and its associated models) operates in practices and how some engineers have successfully counteracted them.
3. Question the dominant definition of sustainable development and its hidden assumptions. As we have seen, the Brundtland definition has become accepted by most engineering organizations perhaps because it does not threaten two key premises: the need for technocratic approach and economic growth. Yet, as shown above, it is possible to critically question these premises, to refocus sustainable development on local communities, and place social justice at the center.
4. Question mainstream methods of community participation. Are these methods about extracting information in order to incorporate communities into national and global markets where they have little leverage? Or are these methods focused on enhancing people's rights, opportunities and resources, thus promoting on social justice?
5. Discern engineering mindsets and ideologies and counteract these in order to create educational and professional practices in engineering more conducive to social justice.

Then and only then, we will be taking significant steps towards an engineering education and practice with the potential to provide socially just solutions to the communities many of us want to serve.

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