Engineers and Community: How Sustainable Engineering Depends on Engineers' Views of People

44

Juan C. Lucena

Abstract

Inspired by the book *From Clients to Citizens: Communities Changing the Course of their Own Development* which shows the importance of rethinking people from clients to citizens in the effectiveness of community development projects, the central argument of this chapter is that the successes or failures of sustainable development (SD) engineering projects depend greatly on how engineers view and engage the people they work with. During the brief history of engineering involvement in SD, engineers have worked with people, viewing them mainly as clients and less so as stakeholders, users, or citizens. Each of these views of people by engineers prescribes the way engineers listen to and work collaboratively with people to turn SD projects into real sustainability.

After briefly conceptualizing listening as the most important element of dialogue and showing how SD might be more sustainable when grounded on specific localities, this chapter maps the different categories – clients, stakeholders, users, and citizens – that engineers have used, or could use, to view the people they try to serve, and how each of these categories shapes the way in which engineers listen and work with them. While listening to and working with people labeled "clients" or "stakeholders" might be more empowering for the status of engineers as experts, it might be less effective in turning SD projects into long-term sustainability. On the other hand, listening to and working with people as "users" or "citizens" might be less empowering for engineers but more effective for sustainability.

J.C. Lucena
Liberal Arts and International Studies, Colorado School of Mines, Golden, CO, USA
e-mail: jlucena@mines.edu

J. Kauffman, K.-M. Lee (eds.), *Handbook of Sustainable Engineering*,
DOI 10.1007/978-1-4020-8939-8_51,

1 Introduction

Sustainable development (SD) and its engineering dimensions do not happen in a vacuum. In addition to institutions, policies, and technologies, SD involves interactions among human actors or agents who hold diverse values and beliefs about what the causes of environmental degradation might be and what is (and is not) to be done to allow human societies to flourish while protecting the ecosystems. This chapter outlines how engineers involved in SD have interacted, and need to interact, with other agents and what consequences these interactions might have for the future of SD.

The most common definition of SD was coined and popularized in the report *Our Common Future*, also known as the Brundtland report UN Secretary General (1987), which defines SD as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). This definition has been overwhelmingly, and often uncritically, adopted by many engineers, most engineering organizations, and high-tech companies committed to SD (World Congress on Sustainable Development–Engineering and Technological Challenges of the 21st Century 2000; Carroll 1993). Perhaps the reason for this uncritical adoption lies in two factors: First, the Brundtland report states that SD "contains within it two key concepts: the concepts of 'needs,' in particular the essential needs of the world's poor ... [and] the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (p. 43). Second, SD requires for its realization, among other things, "a technological system that can search continuously for new solutions." Engineers are clearly attracted to this definition because it allows them to view human "needs" as problems to be solved by engineering solutions. Thus, human needs become parameters in the design of technical systems.

Moreover, this definition recognizes that the limitations to future solutions lie in the current state of technology and social organization, calling for future development of technological solutions and, in many cases, for social engineering. Engineers welcome this reliance on the technological fix with open arms as it puts them in a privileged position as experts in charge of technological solutions and social planning. As such, engineers view others in terms of *needs* whose problems should be solved through technological solutions. But as shown later, although this dominant definition fits well with the traditional relationship between engineers and clients (or expert and non-expert), it also constraints how engineers might engage people in different ways toward the solutions of problems related to SD.

1.1 Engineers as Transformative Agents of SD

SD does not necessarily lead to sustainability. In their insightful paper "Does sustainable development lead to sustainability?" Yanarella and Levine argue that "the lofty goal of global sustainable development requires us, however, to raise the question whether this unfolding vision and strategy may not have congealed into a kind of orthodoxy that inhibits as much as fosters the transition to a condition of ecological and social sustainability" (Yanarella and Levine 1992, p. 760). It is not the purpose of this chapter to settle this issue as the transformation of SD into sustainability is complex and multidimensional. The focus here is on one small yet important piece of this puzzle: *the role that engineers can play in this transformation as they interact with other non-engineering agents involved in SD*. If engineers desire to transform SD efforts into real ecological and social sustainability, in addition to sound institutional/policy frameworks and profound economic and cultural shifts, they need to envision and adopt new roles beyond that of disciplinary experts that have traditionally defined their interactions with those they intend to serve. The transformation of SD into actual sustainability requires *transformative agents* capable of "demystifying the narrow technical expertise of the disciplinary specialist and reconceptualizing the professional expert as knower and moral agent in the process of promoting sustainable development" (Henderson 1981, cited in Yanarella and Levine 1992, p. 769). This new agent should be able to understand the implications of "the democratic statement of global agreements, manifestoes and declarations of principles, and *the rights and duties of all people,* moving well beyond token and self-policing ethical codes of various professional associations [such as engineering codes of ethics]" and operate "within the painful realities and excruciating dilemmas of the global problems they are addressing by involving them in a set of concrete *responsibilities and obligations* to confront those realities and dilemmas in their professional lives, social interactions and personal lifestyles" (Yanarella and Levine 1992) (italics added). For engineers willing to take this new transformative role, responsibilities and obligations include (a) understanding that how they *view* people has significant consequences on how they *interact with* people in dialogue; (b) knowing the strengths and limitations of the ways in which they have interacted with people in the past and present; and (c) understanding that how they view and interact with people in the future can significantly shape their effectiveness in transforming SD efforts into actual sustainability. This chapter maps these responsibilities and obligations for engineers involved in SD.

1.2 Listening as the Cornerstone of Social Interaction

Interactions among humans are complex and involve cognitive, emotional, social, political, cultural, and economic dimensions. This chapter will focus on *listening* as the key activity that facilitates, if done well, or hinders, if done poorly, engineers' interactions with others. Unfortunately, many people in personal, family, professional, and other forms of social interactions have forgotten, or really never learned, to listen. Hence, in this chapter on how engineers interact with others involved in SD, the focus will be on *listening*.

Many factors have contributed to the diminishing of listening in contemporary society. In most consumer societies, for example, spoken or written words – the inputs and outputs of human communication – have become commodities (news, blogs, presentations, papers, training workshops, etc.). At the same time, communication technologies have increased human abilities to stay connected, link to ever-growing networks and groups, and access unlimited amounts of information. Yet these technologies have not necessarily enhanced the ability to listen. As Michael P. Nichols has found, "contemporary pressures have, regrettably, shrunk our attention spans and impoverished the quality of listening in our lives ... Running to and from our many obligations, we get a lot of practice in not listening" (Nichols 2009, p. 2). The availability of communication technologies might be contributing to the increase in the speed and frequency of interactions but not necessarily enhancing the quality of these interactions. Perhaps a commitment to learn to listen to each other, and to reflect on how people view each other might affect listening, will enhance the effectiveness of human interactions.

A recent survey on listening in engineering education found that exchanges among students and others often take place in the form of oral presentations and are reduced to *hearing* followed by immediate reactions in the form of *talking* (Leydens and Lucena 2009). The emphasis is on "what I am going to say now" (output) in response to "what I just heard" (input). The ability of the parties involved to understand each other, to reflect on that understanding, and to try to reach consensus in order to formulate effective and collaborative solutions is lost to the superficiality of an exchange of inputs and outputs. If engineers take the challenge of becoming transformative agents of SD seriously, they will need to re-evaluate their current listening practices and adopt new ones. Then they will be able to effectively interact with others in transforming SD into sustainability. This chapter hopes to contribute in this endeavor.

1.3 Global Versus Local

Engineering is often portrayed as a global profession (Lucena and Downey 2006; Grandin and Dehmel 1997; Baillie 2006; Acosta and Leon 2009; Downey and Beddoes 2010). Supply chains, outsourcing, mergers and joint ventures, and sometimes the mere size and complexity of a technical system create conditions that challenge engineers to move around the world, exchanging knowledge and practices. Engineers have moved around the world for more than two centuries, first from European empires and newly independent nations, and more recently as agents of international development agencies and multinational corporations (Lucena and Schneider 2008). What is different now is the frequency and extent to which these exchanges take place (Friedman 2006). Also increasingly more engineers operate as independent consultants, traveling the world in search of work but not necessarily attached to any particular company for a long period of time (Barley and Kunda 2004). Furthermore larger groups of immigrants are organizing themselves in particular locales and creating nodes of innovation (Saxenian 1999; Varma 2006). Clearly, engineering has been and is increasingly becoming a global activity.

The transfers of knowledge, capital, materials, and technologies happen through the financial networks, supply and demand chains, and multinational corporations (MNCs) that span the globe. The design, development, and production of technical systems rely on these global arrangements. Yet technical systems sooner or later become grounded in localities. The making of things – manufacturing a part, assembling a subsystem, implementing the system, using it, etc. – happens in specific places, within local ecologies and in interaction with local communities of workers, subcontractors, regulators, users, and citizens (Acosta and Leon 2009). This localization of human activity within specific local ecologies has led SD scholars to conclude that the realization of SD into actual sustainable practices depends greatly on being localized. Wary that global visions of SD might work against the actual realizations of sustainable practices, Yanarella and Levine argue that "the very globalizing vision of ecological thinking when transferred to strategizing can militate against the tacking down and institutionalization of self-sustaining processes at lower scales where sustainable development may be more realizable and the results more palpable" (Yanarella and Levine 1992, p. 764). Elaborating further on why the global visions of SD might serve the interests of SD experts, including engineers, SD scholars 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, p. 380).

As stated above, reliance on technological fixes is part of the dominant definition of SD. This clearly appeals to engineers committed to SD, especially if proposed solutions are accompanied by substantial funding from international agencies, national governments, and increasingly by private corporations which have made SD a key business strategy (see examples of adoption of SD as business strategy in Sobkiw 2008). Yet these commitments might not necessarily lead to sustainability. If the practices that support sustainability reside at the local level, that is, in communities that make or break sustainable efforts, then engineers need to shift their focus to dialogues 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 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 (Bridger and Luloff 1999).

Bridger and Luloff's claims raise the following question: if the future of sustainability resides in localized practices how might future engineers understand, dialogue, and effectively work toward sustainable solutions with people involved in SD? In order to begin answering that question, one needs to find out (1) how engineers have traditionally viewed the people they try to serve, (2) how they might view them differently, (3) how engineers' views of people influence how they interact with each other, and more importantly, (4) how engineers' views and interactions with people might have great repercussions in turning SD efforts into sustainability.

2 Engineers and Clients

2.1 Background

Historically, in the USA the professional identity of engineers has evolved in relationship to engineers' interactions with clients. Although this relationship has evolved differently in other countries such as France where, for example, engineers as government functionaries might not see the people they are trying to serve as clients, the engineer-client relationship has taken hold in many places outside the USA, due to the dominance of MNCs around the world, as the sites where engineers work. Here is an outline of this evolution. First, in the late nineteenth and early twentieth centuries as industrial capitalism unfolded, engineering practice moved from the workshop and the private consulting firm to be inside large private industries. With this move, engineers lost significant professional autonomy and their ability to define their relationship to serve the larger public (Layton 1971; Noble 1977). As reflected in the codes of professional conduct that emerged with the advent of professional societies, engineers' loyalty was directed first to their employer and second to their clients. Second, similar to other professions like law and medicine, engineers have sought professional status by defining their relationship to industrial clients. As lawyers and doctors build and maintain expert authority and professional status in their relationship with patients and defendants, engineers do the same when they design for industrial clients (Abbott 1988; Seron and Silbey 2009).

Within this context, the concept of *client* implies a relationship of expert to non-expert where client brings a problem (and constraints such as budget, timeline, size, etc.) to the table while the engineer holds the expert knowledge to propose solutions to the problem. Most codes of ethics reinforce this client-expert relationship as they challenge engineers, for example, to "perform services only in areas of their competence [and] to act in professional matters for each employer or client as faithful agents or trustees . . . " (ASCE).

2.2 Listening

More so than doctors and lawyers who often have one-on-one interactions with their clients, engineers have come to rely on organizational structures and practices that shape how listening to a client takes place. In large technical organizations, listening to clients is often done through a marketing division which translates clients' requirements into design constraints. Engineers translate these requirements into specifications, incorporate them into designs, and later convey them to manufacturing. The business interests of corporations, the channels of corporate communication, and the dominant definition of SD which emphasizes technological fixes, all prescribe listening between engineers and clients in SD contexts. Here, listening has taken the form of a two-way act (dyadic). Leydens and Lucena describe this kind of listening as "basic listening" which "refers to hearing or paying attention to any speaker, such as a client, local villager, coworker, or instructor; thus, listening is framed as a dyadic process of speaking (output) and hearing (input). Basic listening is necessary in any human communicative interaction but, for reasons explained below, is not sufficient for effective and empathetic listening in SD (and arguably, most other) contexts" (Leydens and Lucena 2009, p. 363). Leydens and Lucena summarize the characteristics of *basic listening* as follows:

- Emphasizes one-way relation between speaker and receiver of information.
- Hearing and speaking are considered main outcomes of listening.
- Minimally collaborative and usually applied uni-directionally from top-down (speaker → hearer).
- Minimal attention to accountability and transparency issues.
- Emphasizes traits such as "good speaker" or "good listener."
- Situated contextual issues often considered *unimportant* since focus is on the act of speaking-receiving information.
- Highlights certain skills (speaking, receiving information) while minimizing others (observing, self-reflection, contemplation, inviting participation).
- Integration of multiple perspectives beyond engineer-client often considered less important (Leydens and Lucena 2009, p. 365).

2.3 Implications for Sustainability

In SD contexts, this kind of basic listening is highly problematic, especially in localized contexts. First, those conducting basic listening assume that the complex views, interests, and conflicts of local communities can be reduced to those of a single homogeneous client. While critiques of this kind of listening in development contexts have a long-standing body of literature (Hickey and Mohan 2004; Cooke and Kothari 2004), the critique of how it is done by engineers in SD contexts is fairly recent (Leydens and Lucena 2009). SD scholars working closely with communities have reported how treating people as clients and interacting with them mainly through basic listening has dire consequences for both communities and sustainability. For example, Mathie et al. report "how well-intentioned external agencies (e.g., NGOs, government social workers, donors) have often inadvertently disabled rather than catalyzed communities, converting potentially active citizens, or livelihood producers, into clients in the process" (Mathie and Cunningham 2008, p. 2; see also Eade and Ireland 1997).

In SD efforts that span beyond a local community, this type of listening is also problematic as it leads engineers to assume that cultural differences between speakers and listeners are trivial. As scholars of cross-cultural communications have shown, even when the language of communication among international teams of engineers is the same, there are significant cultural differences that shape, and often impede, knowledge transfer among engineers. For example, Hard and Knie show how the redesign of British ships during WW II came to a standstill at American shipyards as US engineers could not understand the cultural assumptions built into blueprints drawn by their British counterparts. US engineers had to completely redraw the blueprints in terms that were familiar to them (Hard and Knie 1999). Clearly US engineers' commitment to basic listening (a dyadic exchange of information between them and the British engineers) made them omit or ignore important cultural differences of how the two groups conveyed technical information in design blueprints.

Yet cultural differences play a significant role in how different people, including engineers, view and value sustainability. For example, in their study of the importance of social learning and culture for sustainable water management, Pahl-Wostl et al. critique prevailing water management models for their emphasis on unidirectional communication, which reinforces technocratic control over participation, and the belief that communication inputs can be quantified in order to provide optimal outputs: " The prevailing command and control paradigm management is perceived as control. Solutions are technology driven. There is a firm belief that risks [inputs] can be quantified and that optimal strategies [outputs] can be chosen. Zero-sum-games in closed decision space. This cultural framing supports the implementation of controllable and predictable technical infrastructure (reservoirs, dams) [more outputs] based on fixed regulations for acceptable risk-thresholds" (Pahl-Wostl et al. 2008, p. 492). Critical of the main assumptions behind the dominant definition of SD, they conclude that

> There is a growing recognition that in order to address adequately current environmental problems it is necessary to abandon many of the assumptions of the dominant paradigm of resource management about their perceived causes, explanations, and possible remedies and shift toward a more *holistic and integrative* approach . . . New participatory and adaptive water management approaches will not be implemented in sustainable fashion unless they are more deeply rooted in a cultural change in society . . . we cannot understand dynamics and transition toward new management regimes without understanding the interdependence between social learning and culture at different scales (Pahl-Wostl et al. 2008, p. 494) (italics added).

How might engineers socially learn from others in SD contexts and interact with them in more holistic and integrative approaches in order to achieve sustainability? Perhaps engineers need to view the people they are interacting with in SD not as clients but as something else.

2.4 Summary

The engineer-client relationship clearly helps engineers maintain their professional status as experts, and clients get technical solutions to their problems. In this kind of interaction, listening is primarily defined in terms of inputs by the clients (requirements) and outputs by the engineers (technical solutions). Unless there are strong commitments to sustainability in the inputs and outputs, the interaction between engineer and client, with basic listening as its key element, will not likely result in sustainable solutions.

3 Engineers and Stakeholders

3.1 Background

The concept of "stakeholder" became popular through stakeholder theory in organizational management (Freeman 1984) at a time when engineers were becoming increasingly involved in organizational management and the reorganization of US industry (Dertouzos et al. 1989). The concept of stakeholder is an improvement over that of client as it recognizes the diversity of perspectives and interests among those with a stake on a technical solution (project, system, process, etc.). According to Browning and Honour,

> the value of any system can only be measured from the viewpoint of the stakeholders for whom the system provides utility. This is true because the purpose of any system is to provide value and utility to its stakeholders; this is the essence of both the system and the definition of stakeholders. It is therefore necessary first to identify the stakeholders for a system. A stakeholder is any individual or group with a vested interest in a system. Stakeholders are willing to act in some way to preserve their interest (hence "vested" interest). They often include those who derive some benefit from the system and/or make some sacrifice for it (Browning and Honour 2008, p. 190).

Engineers have incorporated stakeholder analysis in engineering systems (Mostashari and Sussman 2005; Buede 2009) and proposed different models and processes to quantify stakeholders' values (Browning and Honour 2008). But has the incorporation of stakeholders in their analysis improved engineers' ability to listen?

3.2 Listening

The engineer-stakeholder relationship presents several challenges to listening. First, there are complex and subjective tasks in *stakeholder identification*. Traditionally, engineers' decisions on who has vested interests in the system have given priority to stakeholders as customers, end users, and builders (Sobkiw 2008; Laplante 2009). New approaches for stakeholder identification, such as value chain analysis and operational analysis, are making inroads into the engineering literature related to SD challenging engineers to consider a wider range of stakeholders. Value chain analysis, for example, focuses on those who derive value from a technological system, mainly users and investors (shareholders), while operational analysis includes all those who are involved in the development, implementation, use, and maintenance of a system (Browning and Honour 2008). Either approach represents an improvement over the way clients are identified in the engineer-client relationship where clients often identify themselves by bringing a problem to engineers. In contrast, stakeholder identification brings into the dialogue perspectives that could otherwise be excluded.

Second, once engineers have identified stakeholders, their next challenge is to figure out *how to listen to them*. Documented cases of stakeholder inclusion show that listening is still dyadic (speaker-receiver). The main difference is that now engineers have multiple input-output interactions taking place at the same time as multiple stakeholders are considered in the analysis.

Third, in these multiple dyadic connections, engineers have to decide *what to listen for*. Here the engineer-stakeholder relationship also presents an improvement over that of engineer-client. Browning and Honour, for example, recognize that besides requirements or specifications, stakeholders also have *values* that need to be recognized and incorporated in system design.

> Unlike most engineering parameters, *value* is a perceived *quality* stemming from subjective *preferences*. Stakeholder preferences are distinct and different from requirements [specs]. Requirements represent a choice made to achieve a specific level of performance and specify acceptability. A system that meets its requirements will provide different value to different stakeholders, depending on their preferences. *Preferences* emanate from individuals, which makes them less amenable to firm analysis (Browning and Honour 2008, p. 192) (italics added).

But how do engineers listen to these preferences and perceive stakeholder values? Although the literature on stakeholder analysis where engineers are doing SD does not include detailed descriptions of the kind of listening taking place, the emphasis on quantitative (acontextual) data gathering through surveys and questionnaires indicates that engineers still rely on basic listening as they *quantify and operationalize these values* into a system design.

3.3 Implications for Sustainability

There is scant evidence showing that inclusion of stakeholders at different stages of the design, development, and implementation of a system ensures its long-term viability and contributions to sustainability (Fiksel 2003). The underlying assumptions that most advocates for stakeholder inclusion make are that (1) at least one stakeholder group will value sustainability, (2) this value will be seriously considered by those designing the system, and (3) it will be incorporated into system design as a key parameter. But these assumptions could be problematic. In the case studies of stakeholder analyses reviewed for this chapter, the incorporation of stakeholders' values and preferences into a system is done through a weighting analysis where key parameters are weighted, first, according to importance to specific stakeholder groups and, second, incorporated into system design according to *how much the system owner values that particular perspective*. For example, in a case study of cell phone system design, although tower height had a 100% weight value for environmental activists, it only represented a 2% weight value for the overall system as assigned by main decision maker: the system owner. Meanwhile, the perspectives of subscribers, corporate management and shareholders *did not* include any parameters related to sustainability, yet they were assigned weight values of 40%, 25%, and 20% respectively. Clearly, coverage, service price, and profit trumped sustainability even when the stakeholder analysis is portrayed as one that includes environmental concerns (Browning and Honour 2008).

There are some important exceptions where the input of less powerful stakeholders was given significant consideration. For example, Suncor, a Canadian energy firm, developed oil sands operations involving multiple stakeholders and acknowledged that stakeholders could provide the company with cost-saving solutions. Once the company had extracted the oil from the oil sands, it had to repair the land to pre-development capability. Aboriginal stakeholders pointed out that "nature rarely produces straight lines" as Suncor engineers tried to smooth and flat the edges of the reclamation area in a linear fashion. By listening to aborigines the company saved money and left the area with a more natural regrowth (Rowledge et al. 1999, p. 74). Yet it is not clear how the perspective of aboriginal stakeholders would have been valued, say at the onset of the development project where key decisions were made about where and how to develop the oil sands. In short, with rare exceptions, even though there might be an impression that stakeholders' inputs are seriously considered, the subjective preferences of system owners tend to override them quite often.

3.4 Summary

Engineers could be either in charge of stakeholder identification and/or identified as a stakeholder group. In first instance, engineers have significant power to determine who is a stakeholder, make sure that stakeholders who value sustainability are included, and that their values are seriously considered in subsequent weighting analyses and system design. As a stakeholder group, engineers would have less influence yet they could include sustainability in their values and preferences. This might happen more in the future as engineering societies challenge their members to make more concerted commitments to sustainability. At the present time, however, from the case studies on SD and stakeholder inclusion reviewed here, it is clear that powerful stakeholders, such as corporate stakeholders or government officials, are often given more weight and consideration.

4 Engineers and Users

4.1 Background

When designing, building, and operating technical systems, engineers often imagine three kinds of users: *passive users,* who accept or reject technological advances through market forces of supply and demand; *reflexive users*, who will use the technologies in the same ways that engineers would (Bardini and Horvath 1995); and *imagined or projected users* "with specific tastes, competencies, motives, aspirations and political prejudices" (Lindsay 2003, p. 31). Different from clients, who provide specific design requirements, these three kinds of imagined users are assumed to receive the benefits of technological solutions without providing explicit input in their designs (other than the projected assumptions that engineers make about them). The view of users as *passive* has been reinforced by studies of production, marketing, and consumption that highlight big companies and advertising agencies as the forces driving consumption (Strasser 1995; Laird 2001). "In these studies, consumption was characterized as a passive and adaptive process and consumers are represented as the anonymous buyers and victims of mass production" (Oudshoorn and Pinch 2005, p. 13). The view of users as *reflexive or projected* has been reinforced by traditional engineering design education where students are often asked to imagine themselves as users, or make assumptions about user groups.

Recent scholarship in science and technology studies (STS) has reconceptualized the concept of user from passive, reflexive or projected to one as *complex agent with creative capacity* "[to] shape technological development in all phases of technological innovation" (Oudshoorn and Pinch 2005). This scholarship makes visible "how the co-construction of users and technologies may involve tensions, conflicts, and disparities in power and resources among the different actors involved" (Oudshoorn and Pinch 2005, p. 16). This chapter considers a number of important contributions from this scholarship:

- The findings in Christina Lindsay's study of present-day users of the TR-80, a computer introduced by Radio Shack almost 30 years ago and thought obsolete with the emergence of Windows systems, that *users can have multiple identities and can perform activities and identities traditionally ascribed to designers*. Present-day users of this obsolete computer define themselves as *"neo-Luddites*" wanting simplicity and reliability of use, when compared with the complexity of today's computer operating systems, or *nostalgic* wanting to go back in time to their first computers, or *resisters* wanting to show new generations of computer users that Microsoft or Apple are not the only options. In addition to these identifiers, users also adopted the roles of "designer, developer, marketer, and technical support" of a computer system (TR-80) that nowadays has no corporate infrastructure to support it (Lindsay 2003, p. 48).
- Ronald Kline's study of resistance to telephone and electrification technologies in rural America and his main finding that instead of being an irrational

act, *resistance* by intended users is an important aspect in the creation of technologies and social relations. By using telephone technologies differently than the intended use by Bell Telephone, farmers pushed the company to "alter the system to permit extended periods of listening in, which allowed farm people to transplant the rural custom of visiting onto the party line" (Kline 2003, p. 65). By resisting to sign up for electricity and to buy appliances, farmers pushed manufacturers to "create new artifacts like the coal and electric combination range, which farm people wove into an altered fabric of rural life" (Kline 2003).
- In her study on the construction of users and nonusers of the Internet, Sally Wyatt re-conceptualizes *nonusers* as active agents that fall in four categories: "*resisters* (people who have never used the technology because they do not want to), *rejectors* (people who have never used the technology, because they find it boring or expensive or because they have alternatives), the *excluded* (people who have never used the technology, because they cannot get access for a variety of reasons), and the *expelled* (people who have stopped using the technology involuntarily because of cost or loss of institutional access)" (Lindsay 2003, p. 18).

What could these new and complex categorizations of users and nonusers mean for engineers' interactions with users in SD contexts? Clearly more complex than listening to clients or stakeholders, *listening to users* challenge engineers to acknowledge, understand, and incorporate a diversity of identities in original designs and to acknowledge their agency in transforming original technologies, and their intended use, into something else.

4.2 Listening

Engineering education rarely trains students to listen, let alone to listen to multiple identities as those found among users (Leydens and Lucena 2009). Yet there are some hopeful signs that engineers are beginning to take users more seriously. For example, computer engineers have begun incorporating users in the design of computer systems in ways that acknowledge their agency as co-creators of technologies (Laplante 2009). After having ignored indigenous farmers at the onset of a design of irrigation software, one group of engineers engaged them as active users after the farmers resisted and rejected features of the software at the initial stages. This engagement led to the co-creation of a more effective irrigation software that the indigenous farmers embraced and used (Dewulf et al. 2005). But these attempts by engineers to incorporate users as active agents do not acknowledge the complexity and diversity of identities that users can adopt, including those of resisters, rejectors, nostalgic, etc. These possibilities challenge engineers to adopt new forms of listening that can illuminate these complexities and help them interact with users in SD contexts more effectively.

Different from basic listening, *contextual listening* has been defined as "a multidimensional, integrated understanding of the listening process wherein listening facilitates meaning making, enhances human potential, and helps foster community-supported change. In this form of listening, information such as cost, weight, technical specs, desirable functions, and timeline [usually the inputs in basic listening] acquires meaning only when the context of the person(s) making the requirements (their history, political agendas, desires, forms of knowledge, etc.) is fully understood" (Lucena et al. 2010, p. 125). To provide a rich context to the interactions among engineers and users/nonusers in SD projects, contextual listening challenges engineers to consider the following dimensions:

- *Integrating history and culture*, which includes finding out the origins of user groups, the history of their interactions with engineers and SD projects, their influence in the different stages of design and implementation, and the diversity among them.
- *Being open to cultural difference and ambiguity*, which includes finding out engineers' strengths and limitations as listeners, their own degree of openness to the diversity of perspectives found among users (especially those that will strongly disagree with the engineers or might want to take the SD project in a different direction), and engineers' tolerance for ambiguity.
- *Building relationships*, which includes developing and maintaining trust, especially with users who might not have the technical qualifications and expertise that engineers have, and a willingness to change in order to build more trusting relationships with the diversity of users.
- *Minimizing deficiencies and recognizing capacities*, which include learning to think about users differently, not in terms of *what they lack* but in terms of *what they can offer* to the design, development, implementation, and future transformations of the SD project in question.
- *Foregrounding self-determination*, which includes understanding how an SD project can be initiated, led, and maintained into the future by users.
- *Achieving shared accountability* which includes learning with the users how a SD project – its results, impacts, and unintended consequences – can move from "ours" or "theirs" to OURS where the responsibility is mutually shared by engineers and users alike.

In contrast to basic listening that clearly shapes the interaction between engineer and client as one between expert and non-expert, *contextual listening* blurs the boundary between expert and non-expert by enabling engineers to acknowledge that users have great deal of agency in the co-creation of technologies. Leydens and Lucena summarized the characteristics of contextual listening as follows:

- Emphasizes multidirectional empathic interactions and dialogue and the building of trust and long-lasting relationships
- Focuses on users' empowerment and project ownership as desired outcomes
- Allows for challenges to engineers' expertise by non-engineering users
- Invites accountability and transparency from all parties
- Emphasizes openness to others, trusting non-engineering users and dealing with ambiguity

- Makes it clear that situated contexts significantly shape individuals' roles and abilities to engage in dialogue
- Aimed at unveiling biases in the interactions among engineers and users
- Promotes multi-perspective coming from diversity of users and nonusers (Leydens and Lucena 2009, p. 365)

4.3 Implications for Sustainability

How might the interactions among engineers and active users in SD projects, with their multiple identities and unintended roles, result in more sustainable solutions? The interactions of engineers with a diverse group of active users will be more likely to transform a SD project into a sustainable one when grounded on contextual listening and situated in the locality where the project or system is to be co-constructed, co-used, and co-maintained. SD scholars Bridger and Lulloff have shown that for a SD project or initiative to be truly sustainable it needs to enhance the following five dimensions: local economic diversity, self-determination, biological diversity and stewardship of resources, reduction of energy use and materials, and social justice (Bridger and Luloff 1999). So, as Kline's study of farmers show, some users with vested interests in the local economy will probably resist an engineering system if it diminishes the community's *local economic or biological diversity*. Acknowledging this resistance because of their commitment to contextual listening, engineers might transform the system into one that enhances these dimensions. Or as Lindsay's study of the TR-80 users show, some users could potentially reconstruct, or even resurrect, a system in a way that enhances community *self-determination*. Again, enabled by contextual listening, engineers' interactions with these types of users will likely yield a system that promotes self-determination. Or as Sally Wyatt's study of Internet nonusers illustrates, engineers committed to contextual listening would be able to identify and interact with the excluded and expelled, and understand how and why a SD project affects *social justice* by denying access to some.

4.4 Summary

Clearly, re-conceptualizing users in more complex and diverse ways, as STS scholars have done, could have positive implications for SD. But adopting a theoretical framework of users is not enough. Engineers need to adopt a more complex form of listening, such as contextual listening, in order to fully understand, value, and interact effectively with a diversity of users. Engineers might relinquish power to users, as users become co-creators of knowledge and technologies, yet this might prove beneficial to sustainability.

5 Engineers and Citizens

5.1 Background

A proposal to engage people in SD as citizens comes from recent critiques of the participatory methods in development projects. A first wave of this literature criticized participatory practices as being just another instrument for controlling or damaging communities. Labeled "participation as tyranny," key participatory approaches, that rely heavily on listening and are among the most popular in development agencies, have been criticized extensively (Cooke and Kothari 2004). Here are the main three:

Beneficiary Analysis (BA), exemplified by Salmen's book *Listening to the People* (Salmen 1987), a classic among development workers, attempts to close the gap between development experts and beneficiaries "by obtaining 'the view from the ground, the grass roots' … accessing the 'voice' of the beneficiary in a way which sample or formal discussions are unable to do … [according to Salmen] 'development planners and managers need to develop their antennae, to extend their eyes and ears into the communities where they are planning and carrying out projects" (Francis 2001, p. 74).

Social analysis, exemplified by the book *Putting People First* by Michael Cernea (Cernea 1985), "the doyen of social science at the World Bank," proposes 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" … 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." Social science now appears to lay a role quite different from that of engineering, as "a means to democratize the planning process itself by facilitating broader participation in it of the development actors themselves … The social scientist is the only kind of expert who is professionally trained to 'listen to the people.' Social knowledge thus developed becomes a 'hearing system' able to amplify the listening for managers and policy-makers, too" (Francis 2001, p. 74).

Participatory Rural Appraisal (PRA), exemplified by World Bank's Participation Sourcebook (1996),

> is thus concerned as much with the development of interpersonal and communication skills and the transformation of attitudes as the acquisition of technical skills: building good rapport by paying attention to both the verbal and non-verbal messages given by interviewers; adopting a learning, rather than lecturing, node; and showing respect for informants, their skills and knowledge. PRA also stresses the sharing of data. In traditional research information is collected from local populations and taken away for analysis and interpretation. PRA, in contrast, offers ownership and control to "respondents," who thereby become participants: "Outsiders are facilitators, learners and consultants. Their activities are to establish rapport, to convene and catalyze, to enquire, to help in the use of methods, and to encourage local people to choose and improvise methods for themselves. Outsiders

watch, listen and learn. Metaphorically, and sometimes actually, they 'hand over the stick' of authority" (Francis 2001, pp. 76–77).

Although a detailed review of the critique of participatory methods is outside the scope of this chapter, it is worth noting that the inclusion of listening as a key activity has not necessarily resulted in benefits for the intended beneficiaries. There are at least three key reasons for this:

- *The tyranny of decision-making and control.* Participatory facilitators often override existing legitimate decision-making processes. This chapter considers whether (and how) SD technocrats and experts, including 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 (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).
- *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 might control the outcome of the meeting). For the purpose of this chapter one needs to explore if engineers' interactions with others in SD contexts might be reinforcing the interests of the powerful (see Mosse (2001) for a detailed analysis of how this happened in a participatory farming systems development project in India).
- *The tyranny of the method.* Participatory methods like those listed above might silence or exclude others that have advantages participatory methods cannot provide (see Ramaswami et al. (2007) for a detailed example of how participatory methods introduced in the 1970s ignored a traditional governance system located in Buddhist temples with dire consequences for water distribution and sustainable farming).

In sum this critique reveals that, first, listeners and listening are biased and political actors and acts that shape the interactions among those involved in SD contexts. Far from creating win-win situations, participatory methods and practitioners could benefit the already powerful and further marginalize the less privileged. Second, most of the listening employed in participatory techniques is *basic listening* – often performed through surveys, questionnaires, and focus groups aimed at collecting lots of data – not *contextual listening* aimed at discovering the history and political dimensions that shape community relations and thus enhancing the interactions among engineers and others. Third, communities are complex, heterogeneous entities with differences of power within them, but participatory techniques tend to ignore these power dimensions and in some cases keep them in place.

A number of SD scholars have proposed a conceptual solution to these problems (Hickey and Mohan 2004). Perhaps the most succinct of these solutions comes from Alison Matthie et al. in their book *From Clients to Citizens* (Mathie and Cunningham 2008), who propose to consider communities as entities where:

- There are complex and conflictive relationships among members and between members and place.
- Relationships are shaped by differences in power and privilege.
- Members have alliances with particular common purpose(s).
- Members should be more appropriately considered *citizens* with rights, power to decide, vote, call projects off, capacity to define problems and propose solutions, intellectual capital, etc.

Treating community members *as citizens* is a significant improvement over any of the relationships analyzed above as the concept of citizen recognizes not only the diversity and complexities of users but also their *rights*. By treating community members as citizens, engineers interacting with them in SD contexts are challenged to recognize that citizen participation in the different stages of projects is not just a methodological nicety but a political right. According to Holland et al., treating community members as citizens

> bridges the gulf between rights in principle and development realities ... it redefines the roles assigned to and the relationships between the state and other development actors. Specifically, *this challenges the role consistently assigned to marginalized and subordinate people as clients or beneficiaries of development and offers instead possibilities of shaping different relationships predicated in the political right to participate in decision-making processes* ... to act as a citizen involves fulfilling the potential that citizenship rights confer on the individual. In this sense, participation is the foundation of democratic practice: a fundamental right that helps to protect and guarantee all others and by doing so highlights the capacities people have to act as agents in their own development (Holland 2004, p. 255) (italics added).

Hence when interacting with citizens in SD contexts, engineers are challenged to consider their diversity and complexity, as engineers have to do with users (see above), *and also to recognize and respect their rights to participate, decide, and even reject a SD project or intervention*.

5.2 Listening

When interacting with citizens, engineers should also use contextual listening, focusing on citizens' rights and looking to understand three key points. First, citizens' own identification and assessment of their rights and the contrast among these, the political rights in a particular locale, and universal human rights. Second, the obstacles that citizens face in accessing those rights. Third, actions to support governments and other social institutions involved in SD in the protection, promotion, and realization of human rights (Holland 2004, p. 257). Hence, in addition to the dimensions described above under the engineer-user relationship, *contextual listening should focus on citizens' rights* as follows:

- *Integrating history and culture*, which now includes finding out the origins of citizens' political rights in a particular locale and how these rights are exercised in this particular culture. After all, as Cleaver argues, "rights do not exist in a vacuum but are embedded in social relations; these very social relations may either enable or constrain the exercise of such agency" (Cleaver 2004, p. 273).

- *Being open to cultural difference and ambiguity*, which now includes finding out engineers' own degree of openness to cultural diversity in relationship with the protection of people's rights, especially in those places that will significantly diverge from the engineers' own locale and view of rights.
- *Building relationships*, which now includes developing and maintaining trust with citizens, so they feel secure to speak about complex issues related to their rights, and with officials in institutions involved in the protection, promotion, and realization of human rights.
- *Minimizing deficiencies and recognizing capacities*, which now include respecting citizens' right to participate at different levels in SD projects and view this as an asset not a deficiency.
- *Foregrounding self-determination*, which now includes understanding how and respecting that citizens have the right to initiate, lead, and maintain (and even terminate) a SD project.
- *Achieving shared accountability*, which now includes accepting a shared responsibility with the citizens of a community to ensure that a SD project – and its results, impacts, and unintended consequences – benefits, or at least does not impede, people's rights and the environmental rights of a community.

5.3 Implications for Sustainability

If engineers and citizens interacting in SD contexts recognize how their rights (local and universal) might be directly linked to the health of the ecosystem around them, then both will likely advance the interests of the surrounding ecosystem when participating in SD projects. For example, since no one can aspire to the right to life or health without potable water or breathable air, engineers and citizens interacting in the co-creation of a SD project will likely protect their right to life and health by protecting water and air sources from pollution or over consumption.

Clearly conflict might emerge between citizens' individual rights and the environmental rights of the community. For example, there might be conflict between individuals' right to decide on the number of offspring they want to have and the community's right to preserve natural resources. Yet, as the examples of community development by active citizens illustrated by Mathie et al. show, resolution will likely "come about either because the positive contribution of those previously excluded has been recognized, or because of the skilled mediation of community leaders, or because community approval of the activities of individuals and groups renders them immune to political manoeuvering by an old guard" (Mathie and Cunningham 2008, p. 360). In fact when people are viewed, and view themselves, as citizens of a community, *rights and responsibilities* toward environmental sustainability are likely to be more balanced within the political space of a community. As Matthie et al. have demonstrated in their illustrative collection of case studies in sustainable community development, "many of the cases here demonstrate that rights and responsibilities are intertwined, that citizenship is as much about mutual support and collective effort as it is about occupying a space to claim rights from the state. Most of the cases in fact show how these two dimensions of citizenship can overlap or mutually reinforce each other, and how it is community initiative and community innovation that sets the terms of engagement with state actors rather than the other way around" (Mathie and Cunningham 2008, pp. 361–362).

By viewing and interacting with people as citizens, engineers can contribute to enhancing people's rights in relationship to their environment and their ability to claim rights from the state. For example, a case study of an engineer facilitating community mapping for water management in Honduras shows how the engineer's view of community members as citizens with rights translates into her giving them the power to map their own watershed, water use, water habits (cooking, hand washing, flushing, etc.), water needs for the future, and those in the community directly responsible for these (e.g., farmers' fertilizing practices have direct impact on watershed, teachers' classroom practices have direct impact on children's hand washing, and so on). As this engineer assists community members to create *their own* map, the latter come to clearly recognize how their individual rights interact with the environmental rights of the community (e.g., the impact of individual practices executed in private property on the watershed) and what rights to claim from the state (e.g., protection of the watershed, funding for water education in public schools, etc.) (see Lucena et al. (2010), Chap. 7 for full description and analysis of this case study).

5.4 Summary

When engineers view and interact with people as citizens with rights, engineers can make significant contributions to transform SD efforts into sustainable ones. Citizens will be empowered by their rights to initiate, participate in, and even terminate if they deem proper, SD projects and be more likely to share responsibility for the sustainability of their local ecosystem.

Engineers who practice contextual listening with a focus on rights will be able to recognize conflicts between rights and responsibilities, as they will be in tune with citizens' rights and the community's environmental rights, and to serve as catalysts in sustainable solutions as they will likely be trusted by community citizens and their leaders.

6 Conclusions

Linking the global with the local. Supply chains enhance engineers' ability to manufacture products with materials, parts, and subsystems that come from different corners of the globe. Yet at each node in the supply chain, there is a locality, where people and a local ecosystem will be affected by how the particular part or subsystem will be manufactured (e.g., the potential waste products released into the nearby atmosphere and water supply). It is at these nodes where engineers committed to sustainability can make a difference by viewing and interacting with people as citizens, respecting their rights, allowing them to take control of their own destiny, and serving as translators of how global practices affect local communities and vice versa.

Clearly, there are global problems such as climate change that can hardly be solved by local practices alone. Engineers could contribute toward the solutions of these problems by interacting with people as citizens and co-creating sustainable solutions but only with limited results. These global problems require larger solutions in the form of concerted policy and investment efforts by officials at the levels of nation-state, international organizations, and multinational corporations and radical changes in public opinion, manufacturing, and consumption patterns.

Moving from clients to citizens. This chapter has shown how the dominant definition of SD reinforces the engineer-client relationship and how basic listening does not allow engineers to engage others in effective ways to find sustainable solutions. The engineer-stakeholder relationship is only effective if stakeholder groups bring sustainability to the table and those groups are taken seriously in the final system design by those in control of the system. The engineer-user relationship allows for the inclusion of diverse and complex perspectives and opens the possibility of users becoming co-creators of technologies and sustainable solutions. This leveling of the expert-nonexpert relationship might mean a loss of power and status by engineers but a gain in transforming SD into real sustainability. Meanwhile, the engineer-citizen relationship recognizes people's rights and responsibilities of and is more likely to yield sustainable solutions.

From basic to contextual listening. Hopefully, it has become clear that how engineers view the people they are trying to serve shapes how they interact with them in SD projects. When working with clients and stakeholders, engineers are barely challenged to listen, mainly through basic listening, and will likely maintain a higher status as experts. When working with (non)users and citizens, engineers are seriously challenged to adopt a more complex type of listening (contextual listening), to be on a more equal playing field and in some cases to relinquish power as users or citizens become co-creators of technologies. A shift from basic to contextual listening requires more time, work, patience, and commitment (and perhaps come at the expense of engineers' status and power) yet it allows engineers to interact with people in more effective ways toward sustainable solutions.

References

A.D. Abbott, *The System of Professions: An Essay on the Division of Expert Labor* (University of Chicago Press, Chicago, 1988)

C. Acosta, V.J. Leon, *Global Engineering: Design, Decision Making, and Communication* (CRC Press, London New York, 2009)

A. Mostashari, J. Sussman, Stakeholder-assisted modelling and policy design process for environmental decision-making. J. Environ. Assess. Policy Manage. **7**(03), 355–386 (2005)

UN Secretary General Report of the World Commission on Environment and Development: Our Common Future – A/42/427 Annex – UN Documents: Gathering a body of global agreements, http://www.un-documents.net/wced-ocf.htm (1987)

ASCE: Code of ethics, http://www.asce.org/Content.aspx?id=7231 (1914)

C. Baillie, *Engineers Within a Local and Global Society* (Morgan and Claypool, San Rafael, California, 2006)
T. Bardini, A.T. Horvath, The social construction of the personal computer user. J. Commun. **45**(3), 40–66 (1995). doi:10.1111/j.1460-2466.1995.tb00743.x
S.R. Barley, G. Kunda, *Gurus, Hired Guns, and Warm Bodies : Itinerant Experts in a Knowledge Economy* (Princeton University Press, Princeton, 2004)
J.C. Bridger, A.E. Luloff, Toward an interactional approach to sustainable community development. J. Rural Stud. **15**, 377–387 (1999)
T.R. Browning, E.C. Honour, Measuring the life-cycle value of enduring systems. Syst. Eng. **11**(3), 187–202 (2008). doi:10.1002/sys.20094
D.M. Buede, *The Engineering Design of Systems: Models and Methods* (Wiley, New York, 2009)
W.J. Carroll, World engineering partnership for sustainable development. J. Prof. Issues Eng. Educ. Pract. **119**(3), 238–240 (1993)
M.M. Cernea, *Putting People First: Sociological Variables in Rural Development* (Published for the World Bank [by] Oxford University Press, New York, 1985)
F. Cleaver, The social embeddedness of agency and decision-making, in *Participation: From Tyranny to Transformation* (Zed Books, London New York, 2004), pp. 271–277
B. Cooke, U. Kothari. *Participation, the New Tyranny?* (Zed Books, New York, 2004)
M.L. Dertouzos, R.K. Lester, R.M. Solow, *Made in America: Regaining the Productive Edge* (MIT, Cambridge, 1989)
A. Dewulf, M. Craps, R. Bouwen, F. Abril, M. Zhingri, How indigenous farmers and university engineers create actionable knowledge for sustainable irrigation. Action Res. **3**(2), 175–192 (2005)
G.L. Downey, K. Beddoes, *What is Global Engineering Education for?: The Making of International and Global Engineering Educators* (Morgan & Claypool, San Rafael, 2010)
D. Eade, *Capacity-Building: An Approach to People-Centred Development* (Oxfam, Ireland, UK 1997)
J. Fiksel, Designing resilient, sustainable systems. Environ. Sci. Technol. **37**(23), 5330–5339 (2003). doi:10.1021/es0344819
P. Francis, Participatory development at the world bank: the primacy of process, in *Participation, the New Tyranny?* (Zed Books, London New York, 2001), pp. 72–87
R.E. Freeman, *Strategic Management: A Stakeholder Approach* (Pitman, Boston, Massachusetts, 1984)
T.L. Friedman, *The World is Flat: A Brief History of the 21st Century* (Farrar, Straus, and Giroux, New York, 2006)
J.M. Grandin, E.W. Dehmel, Cross-cultural issues in educating engineers for the global workplace. J. Lang. Int. Bus. **8**(2), 1–15 (1997)
M. Hard, A. Knie. The grammar of technology: german and french diesel engineering, 1920–1940. Technol. Cult. **40**(1), 26–46 (1999)
H. Henderson, *The Politics of the Solar Age: Alternatives to Economics* (Doubleday, Garden City, New York, 1981)
S. Hickey, G. Mohan, *Participation: From Tyranny to Transformation? Exploring New Approaches to Participation in Development* (Zed Books, London New York, 2004)
D. Holland, Beyond the technical fix? Participation in donor approaches to rights-based development, in *Participation: From Tyranny to Transformation* (Zed Books, London New York, 2004), pp. 252–268
R. Kline, Resisting consumer technology in rural America: the telephone and electrification, in *How Users Matter: The Co-Construction of Users and Technology* (MIT, Cambridge London, 2003), pp. 51–66
P.W. Laird, *Advertising Progress: American Business and the Rise of Consumer Marketing* (JHU, Baltimore, 2001)
P.A. Laplante, *Requirements Engineering for Software and Systems*, 1st edn. (CRC, Redmond, 2009), http://beta.crcpress.com/product/isbn/9781420064674

E.T. Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (The John Hopkins University Press, Baltimore, 1971)
J. Leydens, J. Lucena, Listening as a missing dimension in humanitarian and sustainable community development efforts: the engineering curriculum as a potential learning inhibitor. IEEE Trans. Prof. Commun. **52**(4), 359–376 (2009)
C. Lindsay, From the shadows: users as designers, producers, marketers, distributors and technical support, in *How Users Matter: The Co-Construction of Users and Technology*. Inside Technology (MIT, Cambridge London, 2003), pp. 29–50
J. Lucena, G. Downey, A systemic approach to global competency for engineers, in *ASEE Annual Conference and Exposition*, Chicago, 2006
J. Lucena, J. Schneider, Engineers, development, and engineering education: from national to sustainable community development. Eur. J. Eng. Educ. **33**(3), 247–257 (2008)
J. Lucena, J. Schneider, J.A. Leydens, in *Engineering and Sustainable Community Development*, ed. by C. Baillie (Morgan & Claypool, San Rafael, 2010)
A. Mathie, G. Cunningham, *From Clients to Citizens: Communities Changing the Course of their Own Development* (Practical Action, Warwickshire, 2008)
D. Mosse, "People's knowledge", participation and patronage: operations and representations in rural development, in *Participation, the New Tyranny?* (Zed Books, London New York, 2001), pp. 16–35
M.P. Nichols, *The Lost Art of Listening: How Learning to Listen Can Improve Relationships* (Guilford, New York, 2009)
D.F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (Oxford University Press, New York, 1977)
N. Oudshoorn, T. Pinch, in *How Users Matter: The Co-Construction of Users and Technology* (MIT, Cambridge, Massachusetts, 2005)
C. Pahl-Wostl, D. Tabara, R. Bouwen, M. Craps, A. Dewulf, E. Mostert, D. Ridder, T. Taillieu, The importance of social learning and culture for sustainable water management. Ecol. Econom. **64**(3), 484–495 (2008)
A. Ramaswami, J.B. Zimmerman, J.R. Mihelcic, Integrating developed and developing world knowledge into global discussions and strategies for sustainability. 2. Economics and governance. Environ. Sci. Technol. **41**(10), 3422–3430 (2007). doi:10.1021/es0603047
L.R. Rowledge, R.S. Barton, K.S. Brady, J.A. Fava, *Mapping the Journey: Case Studies in Strategy and Action Toward Sustainable Development* (Greenleaf Publishing, Sheffield, United Kingdom, 1999)
L.F. Salmen, *Listen to People: Participant-Observer Evaluation of Development Projects* (Oxford University Press, New York, 1987)
A. Saxenian, *Silicon Valley's New Immigrant Entrepreneurs* (Public Policy Institute of California, San Francisco, 1999)
C. Seron, S.S. Silbey, The dialectic between expert knowledge and professional discretion: accreditation, social control and the limits of instrumental logic. Eng. Stud. **1**(2), 101 (2009). doi:10.1080/19378620902902351
W. Sobkiw, *Sustainable Development Possible with Creative System Engineering* (CassBeth, New Jersey, 2008), http://books.google.com/books?id=7WJppXs-LzEC
S. Strasser, *Satisfaction Guaranteed: The Making of the American Mass Market* (Smithsonian Institution Press, Washington, DC, 1995)
R. Varma, *Harbingers of Global Change: India's Techno-Immigrants in the United States* (Lexington Books, Lanham, 2006)
World Congress on Sustainable Development–Engineering and Technological Challenges of the 21st Century, in *World Congress on Sustainable Development–Engineering and Technological Challenges of the 21st Century* (Tata McGraw-Hill Pub, Calcutta New Delhi, 2000)
E.J. Yanarella, R.S. Levine, Does sustainable development lead to sustainability? Futures **24**(8), 759–774 (1992). doi:10.1016/0016-3287(92)90105-O