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Designs on development: engineering, globalization, and social justice

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This article critically appraises 'engineering for development' initiatives and seeks to imagine new models of interaction that incorporate social justice goals more effectively. In recent years, interest in engineering for development has surged within engineering communities in the US and around the world. While worthy of recognition and praise for directing engineers' attention to the problems arising from global economic inequity, many engineering-for-development programs share problematic assumptions about technology's role in community development and fail to grapple with the economic and cultural structures that direct (implicitly or explicitly) most development interventions. Using a case study approach, this article draws out some of these assumptions and shows how they impede the achievement of social justice goals – both in the context of specific development interventions as well as in the context of engineering as a professional activity. The first of two cases involves an interdisciplinary collaboration between two universities in Nicaragua and two in the US focused on educational capacity building for product design with an eye to local economic empowerment. Social justice considerations discussed here include power relations throughout the collaboration among individuals and institutions – including what constitutes meaningful community involvement – and the economic models assumed when launching products in the marketplace. The second case involves the work of a non-governmental organization in Sri Lanka and its approach to community development through renewable energy technologies. In this case, social justice considerations include questions of control over project decision making as well as power inequities inherent in development assistance. In both cases, concerns of technical functionality tend to occlude social power imbalances and epistemological divergence, leading to projects that inadvertently extend social injustices.

Keywords: engineering for development; service learning; appropriate technology; social justice

Introduction: engineering for development

In recent years, interest in 'engineering for development' has surged within engineering communities in North America and around the world.[1] Dozens of engineering educational institutions sponsor development projects abroad, and

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[1]Different but overlapping terms are used to mark the same domain including community development engineering, humanitarian engineering, appropriate technology, and others.

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many offer courses or even entire programs in the area, with well-established programs at Massachusetts Institute of Technology (MIT), Duke, the University of Colorado at Boulder, and several other universities.[2] Non-governmental organizations (NGOs) highlighting engineering's role in development have also recently emerged around the world, promising to meet basic human needs or even 'end poverty' through the implementation of technology. These two threads come together in development organizations with a strong educational focus, such as Engineers without Borders USA, Engineers without Borders Canada,[3] and Engineers for a Sustainable World, each of which has dozens of affiliated university campus chapters. Like engineering educational programs, these engineering-for-development NGOs rely heavily on engineering students and young professionals to carry out ground-level development initiatives. Hence, in addition to the challenge of implementing successful development projects abroad, these efforts face the added (and not always synergistic) goal of providing participants with cross-cultural and other educational experiences.

While worthy of recognition and praise for directing engineers' attention to problems arising from global economic inequity, many engineering-for-development initiatives share problematic assumptions about technology's role in community development and fail to grapple with the broader forces that direct – implicitly or explicitly – most development interventions. By placing technical functionality at the center of development work, engineering-for-development projects tend to obscure non-technical dimensions of development work that are critical to achieving social justice goals. Three such dimensions highlighted in this article are: (1) social power relations among development workers and community members; (2) far-reaching structural constraints, such as neo-liberal economic policies; and (3) questions of project sustainability, in particular as it is enabled by host communities taking active responsibility for project outcomes over the entire course of the project's evolution.[4] Rather than achieving the social justice goals many engineering-for-development projects explicitly strive for, inattention to these dimensions of their work risks further entrenching injustices.

The article uses two case studies to draw out problematic practices and assumptions underlying many engineering-for-development initiatives and shows how they impede the achievement of social justice goals – both in the context of specific development interventions and in the broader context of engineering as a professional activity. The first case is of an international engineering exchange project focusing on educational capacity building for product design with an eye to local economic empowerment. The case involves interdisciplinary collaboration between two universities in Nicaragua and two in the US over a relatively short

[2]Additional programs are described in Riley, "Resisting Neoliberalism in Global Development Engineering," 2007.

[3]Legally and administratively independent EWB organizations exist in many countries around the world. Many, but not all, of these organizations collaborate through EWB-International, which helps coordinate activities among its membership.

[4]As in much of development discourse, "project sustainability" refers here to on-going project viability, primarily in organizational, financial, and technical realms, and not the more current usage in the North: environmental sustainability. For an analysis of "sustainability" as an integrative concept – across socio-cultural, technical, financial, and ecological realms – for engineering education, see Nieusma, "'Sustainability' as an Integrative Lens for Engineering Education," 2009.

period, highlighting challenges commonly faced in international engineering exchange programs. Social justice considerations discussed here include power negotiations throughout the collaboration, among both individuals and institutions; the extent to which community involvement was meaningful; and the economic models assumed for launching products in the marketplace.

The second case involves a network of technology-oriented development organizations in Sri Lanka, focusing on the integrated development approach taken by one local organization in particular. Unlike the Nicaragua case, here there are highly experienced development organizations staffed by experts with deep understandings of local contexts and long-term commitments to host communities. Despite being highly reflective of the nature of the challenges, this group similarly struggles to de-center technology in their engineering-for-development projects. Social justice dimensions of this case include questions of project 'ownership' and the associated power sharing between development workers and intended beneficiaries[5] and how they impact long-term project sustainability. In both of the cases, assumptions about technology, power imbalances, and epistemological divergence are used as a lens for reconsidering the motivations underlying engineering-for-development work and the extent to which such work might inadvertently extend social injustices.

Though only two of thousands of possible cases of engineering-for-development activity, these communicate some of the major challenges facing engineers working to enhance social justice through technology-oriented development projects. But these cases also offer the opportunity to move beyond critical appraisal of engineering-for-development initiatives by providing insight into new modes of engagement that more directly facilitate achieving social justice goals. The cases highlight a range of ways injustices slip into well-motivated projects and how attention to non-technical dimensions of technology projects is needed to counter them. We argue that by identifying the major conceptual traps underlying many technology-based development efforts and by understanding the broader cultural and economic contexts in which most development projects are situated, engineering development volunteers and professionals will be positioned to contribute more effectively to sustained development efforts and to learn more about the multifaceted nature of 'development' while going about their work.

Our analysis unfolds in four steps. First, in the following section, we provide a bit of context for contemporary engineering-for-development activities, briefly reviewing historical approaches to technology-based development, with a focus on appropriate technology, and comparing them to present circumstances. Second, we introduce our case material – from development projects in Nicaragua and Sri Lanka in turn – and then, third, identify generalized lessons the cases offer in terms of the role of technology in development assistance, power sharing, and attention to far-reaching structural constraints. Finally, we conclude with reflections on alternative modes of engagement that displace technical criteria from the center of

[5]The term "intended beneficiary" directs attention to two facets of development aid. First is that the underlying motivation of development work is to "benefit" people, usually highly marginalized people. Perhaps obvious when stated, this goal often gets lost in the shuffle of project implementation. Second is that despite intentions, many recipients of assistance do not, at the end of the day, benefit from development projects. Strictly speaking, they are not always "beneficiaries." This distinction is made in Dudley, *The Critical Villager*, 1993.

development work, putting technology projects more directly in the service of social justice goals. Although our analysis often follows the path of critique, ultimately we offer a message of hope in the potential of engineering expertise to reduce suffering, to improve health and happiness, and to create a more just global order.

Engineering for development in historical context

In many respects, 'engineering for development' is a modern-day instantiation of the appropriate technology movement, which gained prominence – along with other counter-cultural movements – in the West in the 1970s. The idea of appropriate technology has roots in Gandhism and other technology appropriation efforts carried out throughout South Asia dating back to the 1920s, but was popularized by E. F. Schumacher's seminal work of 1973, *Small is Beautiful*. The appropriate technology movement that Schumacher popularized (and extended) built considerable momentum over the 1970s, as it sought to link technology development with the empowerment of marginalized social groups, especially the world's poor.

The appropriate technology movement was spurred by notable failures of 'technology transfer' throughout the 1950s and 1960s, where Western technologies were literally picked up out of Western contexts, placed in very different contexts in developing countries, and expected to function equivalently. Of course, these technologies did not function equivalently, due to differences in social, political, material, environmental, organizational, and other contextual conditions. Despite their criticism of direct technology transfers, early appropriate technologists remained convinced of the potential for properly designed technologies to play a central role in the development of poor communities.[6] Like Schumacher, many appropriate technology thinkers came to define 'appropriateness' as the degree to which a technology fits its specific context of use; they avoided strictly delineating which technologies are appropriate and which are not.[7] Targeted directly to the needs of poor or otherwise marginalized people, 'appropriate technologies' are widely understood to be relatively low cost, locally made and serviced, and well suited to their cultural, material, and ecological contexts.[8]

Although the appropriate technology movement lost considerable steam in the West in the 1980s,[9] it was carried on by numerous development organizations in non-industrialized countries, including most notably by the Intermediate Technology Development Group (ITDG, now Practical Action).[10] Today, engineering-for-development initiatives tackle the same basic problems and confront many of the same challenges faced by the original appropriate technologists. These questions persist:

[6]Williams, "Small-Scale Technology for the Developing World," 2008.
[7]For an excellent historical account of the appropriate technology movement, see Willoughby, *Technology Choice*, 1990.
[8]Smillie, *Mastering the Machine*, 1991.
[9]In the West, the appropriate technology movement combined with environmentalism and largely became absorbed by the green design movement. See Whiteley, *Design for Society*, 1993, and Nieusma, "Alternative Design Scholarship," 2004a for reviews of these and other related threads of engineering and design practice.
[10]Incidentally, ITDG was founded by Schumacher and colleagues in 1965, several years before publication of *Small is Beautiful*. Practical Action now operates in seven countries and regions in the global South in addition to its international headquarters in the UK, employing about 500 full-time staff worldwide (Practical Action, "About Us," 2009).

What roles should technology play in development? What are the best mechanisms for transferring knowledge and skills necessary to maintain new technologies? What is the ideal relationship between 'giver' and 'receiver' of technology aid?

Despite continuity of the underlying challenges, much has changed in the world since the 1970s, providing new opportunities for, but also new constraints on, technology-oriented development projects. New opportunities are created by new communications technologies, fostering information exchange of all sorts, but especially between countries and institutions providing development assistance and those receiving it. New opportunities for development exchange programs are also created by increased mobility, especially of potential development volunteers; today, many students in the North can afford to travel to developing countries, making short trips by large numbers of students feasible.[11] On the other hand, new constraints have arisen as global economic policies pressure many poor nations to adopt free-trade arrangements that expose locally created technologies to international competition.[12]

With over four decades of experience with appropriate technology in the South, why do so many engineering-for-development initiatives still struggle to produce successful, sustained outcomes? One compelling answer to this question is, simply, that 'Development is difficult.' Surely, this claim is a truism for anyone experienced in development work. But were this truth widely known, we might expect to see fewer projects initiated with more investment dedicated to each. Instead, the past decade has seen a proliferation of engineering-for-development projects, and this fact provokes a different answer to the question of why engineering-for-development projects struggle with success: 'Our models for development must be wrong.' Although easy enough to express, the meaning of this 'answer' requires systematic consideration.

If the enduring lesson of the appropriate technology movement is that 'context matters,' so that now nearly all technology-oriented development projects attempt to understand the local context as the first step in their process, then we must look at how, exactly, context is communicated to and engaged by participants in engineering-for-development projects. This matter is urgent for international exchange programs, as in the Nicaragua case that follows, where participants come from very different class, cultural, and linguistic backgrounds compared to intended-beneficiary communities. This is especially true when exchange programs are short in duration, which provides a structural constraint to what understanding (and how much and with what depth) is even possible for volunteers to achieve. But it is also true for locally-situated development interventions, as the Sri Lanka case shows when development workers move between the commercial center, Colombo, and the rural villages they serve. As long as faulty assumptions of the role of technology in 'solving' development problems persist – as might be expected among a large number of engineers and engineering students – the relevance of local context

[11]For a historical outline of how engineering students began traveling under the umbrella of 'development' since the 1960s, see Jesiek and Beddoes, "From Diplomacy and Development to Competitiveness and Globalization," Under review.

[12]KickStart's move away from local manufacturing of treadle pumps in Africa to take advantage of cost savings in China is just one example of how appropriate technology itself is changing to accommodate globalized economies, despite the potentially "inappropriate" undermining of local economies in the communities of focus. See McGregor, "Pumping out the Profits," 2006.

is likely to disappear when it comes to the technology design process. Our cases investigate precisely these challenges, and raise a range of related questions about how engineering-for-development projects might be more successful, both in their own terms and in terms of achieving greater social justice.

Engineering for development case studies

This section reviews two very different case studies. The first is of an international student and faculty exchange project between institutions in the US and Nicaragua, which faced many predictable challenges to development exchange efforts. This case shows how pragmatic concerns quickly overwhelmed participants' attention, pushing social justice matters to the back seat even as they ostensibly motivated the project. The second case is of a community of appropriate technology development workers in Sri Lanka, which serves to highlight the complexity of technology-oriented development work even in the absence of the constraints imposed by international exchange programs. The case shows that achieving social justice in the context of technology-centered development work is difficult even with situated cultural awareness, inter-organizational alignment, and a diverse, highly experienced expert workforce. In both of the cases, we see how well-worn barriers to socially just interactions – excessive attention to technology products and infrastructure, inattention to power imbalances, and uncritical use of problematic models of development assistance – are magnified in engineering-for-development work.

Product entrepreneurship in Nicaragua[13]

This case concerns an engineering exchange development project carried out as a partnership of two institutions in the city of Estelí and two institutions in the US:

- Universidad Nacional Autónoma de Nicaragua – Facultad Regional Multi-disciplinaria (UNAN-FAREM) (regional campus of the national university).
- Universidad Popular de Nicaragua (UPONIC) – (private technical institute).
- Grand Valley State University (GVSU) – (public comprehensive institution).
- Smith College (private women's liberal arts college).

The collaboration sought to meet a variety of individual and institutional goals, at the same time as serving the interests of the residents of Estelí. One of the authors (Riley) was a participant in this project; the observations below are based on her experiences, captured in reflections made and notes taken during the course of the project.

In 2005, Nicaraguan administrators and faculty met with faculty from GVSU (including one business and one engineering professor), who had traveled to the country on one of several regular health aid trips organized by GVSU's nursing school.

[13]For additional information on this case, see Riley et al., "Design for Economic Empowerment," 2009. This case study necessarily represents one participant's perspective and reflections on work that involved a large team; each team member would no doubt emphasize different events as important or highlight different aspects of the case. It is important to discuss the shortcomings of all development projects frankly. Only in so doing can one examine the phenomenon of global development as an aspect of engineering education, and work toward social justice in that frame.

The Nicaraguan faculty and administrators identified the potential in FAREM's business program to address the pressing community problems of unemployment and poverty, and expressed a desire to expand the program's capabilities beyond service businesses to include product design and development. UPONIC offered its programs, facilities, and students focused on technological skills.

While it was clear to all participants that technology can play an important role in raising the standard of living in developing nations, the US faculty especially expressed the practical need and moral imperative to avoid past failures in engineering development projects that have focused on one-way technology transfer from wealthy donor nations, that have not properly considered cultural context, that have not meaningfully involved community members, or that have not realized opportunities to utilize and build local resources for economic empowerment.[14] Familiarity with existing engineering development projects made some team members additionally wary of how US students would understand and attempt to convey their expertise in a service-learning context. A related area of concern was the management of tensions that were likely to arise when the goals of serving a community competed with the goals of the learning experience.[15]

Over several visits and many discussions, the project developed to incorporate multiple goals involving collaborative education of students in both countries. In December 2006, the emerging team – including faculty and administrators from the four schools – committed to work together to enhance curricula at the two Nicaraguan universities by incorporating engineering design and local manufacture of goods with business and marketing. The group was multidisciplinary from its inception, involving faculty and students from engineering, business, Latin American studies, economics, Spanish, English, architecture, and communications. The goal was to build educational capacity for developing products. Knowing that any single product has a high likelihood of failure, focusing on capacity building[16] would increase the chance of long-term success for the institutions and for economic development in Estelí.

It is important to note that Estelí consists of multiple, distinct communities; whereas the university community represents individuals with relative economic privilege, the general population of Estelí is less privileged. Faculty and students in Estelí proposed a 'local' service-learning project, with the university community intending to create jobs in the general population, which has significant unemployment. Thus, a parallel can be drawn between the relationship of the Estelí university participants and the Estelí residents on one hand and the US university participants and their Estelí university partners on the other hand. In both instances, external participants sought to stimulate development activity – product development and curriculum reform respectively – within a distinct 'local' community.

A two-week course was developed and offered for the first time in Nicaragua in May 2007 with five students from each of the four institutions. Five US faculty and five Nicaraguan faculty participated. Students worked in cross-institutional and multidisciplinary teams, following a product design process for developing markets

[14]Hammer, "Why Projects Fail," 1994.
[15]Riley and Bloomgarden, "Learning and Service," 2006.
[16]Here, capacity building refers to upgrading the range of skills and competencies required for sustaining development activity, including but not limited to economic activity. For an introduction to the concept as used here, see Eade, *Capacity-Building*, 1997.

and technologies in Estelí for product-based entrepreneurship using locally available materials and skills. Following the May course, students at each of the four institutions continued the collaboration, pursing product ideas developed in May, including a removable bicycle seat to accommodate a second rider, a pressurized-water patio washer, a vegetable cutter, a bicycle-powered washing machine, and a mechanical fan that operated without electricity.

The course was conducted primarily in Spanish, with three interpreters assisting: one US student (native speaker), one US faculty member (nearly fluent), and one hired interpreter (Estelí resident). Class met in the afternoons. As Nicaraguan students and faculty had other responsibilities, US students and faculty spent mornings in a nearby language school (and evenings housed with local families). Language instruction varied according to ability, and included field trips to area businesses and cooperatives that made products ranging from electronics to boots and from pepper sauce to paper.

Product over process

The faculty team designing the product entrepreneurship course in Nicaragua made a strong, conscious effort to frame the project educationally around process rather than product. Rather than focusing all participants' attention on a specific, community-based development project, this collaboration sought to focus on capacity building. As part of the educational framing, team members agreed that US students were not to be in the position of 'expert' as they did not play an active role in capacity building among the Nicaraguan participants. Instead, their role was to attend the course and learn about development alongside Nicaraguan students, addressing the goal articulated by US faculty that American students need to learn about technology and development in a context where social justice was the explicit goal.[17] In this framing of the project, students were to engage in an exchange of both disciplinary knowledge and knowledge about their individual cultural contexts. They also were to serve as pilot students for the educational capacity building facet of the project.

However, the capacity-building framing of the project was irregularly emphasized with students, and because the topic of the course was product entrepreneurship, it was necessary for students to focus significant attention on new product development for the Nicaraguan context. The specific service-learning tasks surrounding the larger goal of local economic empowerment through product design and entrepreneurship pulled in two directions. These tasks were intended to direct student attention to *process* (i.e. innovation grounded in community participation) but ended up encouraging students to work to produce a *product*. While each product was to be just one educational example that demonstrated the process, it became an end in itself for the team that developed it. Holding these two components of the larger project in productive tension was difficult for students and faculty alike. In both the US and Nicaraguan contexts, there was a tendency to fall back on the product over the process. We will review some of the reasons for this product-over-process orientation, which were structural and disciplinary, reflecting the values and priorities of the fields and institutions involved.

[17]Riley et al., "Design for Economic Empowerment," 2009.

In both countries, there was a structural imperative to produce a product in order to advance the project. In the US, the faculty members' attempts to acquire both public and private grant funding produced reviews that suggested focusing on a particular product. Funders wanted to know there was a specific material object at the center of the development effort. In Estelí, where each institution is a branch of a larger national educational institution, in order to gain administrative support for the work, it was also necessary to produce results in the form of a tangible product. Similarly, relations with the citizens of Estelí pointed the project participants to specific products, so that community members could imagine the project's benefits in creating local jobs or in meeting an existing or projected consumer need. This focus on a specific technology or product as a measure of project success obscures the larger goals related to capacity building, and to developing a more socially just framework for development-oriented exchange programs.

The selection of students at each institution reflects different institutional values, individual faculty goals, and disciplinary priorities. At GVSU, selection favored students with technical expertise who had already taken a course in product design and entrepreneurship. At Smith, selection favored students with Spanish language expertise and readiness to work cross-culturally, with a balance of engineers, economists, and Latin Americanists. At UPONIC, volunteers were solicited who were interested in and open to a new educational experience. And at FAREM, students with course experience in the small business development program were recruited. Although there was a mix of priorities represented in the overall selection process, the fact that some students were selected because of their prior knowledge of course material and technical ability created an expectation, internalized by those students, that disciplinary content expertise was what was important.

The prioritization of engineering expertise in particular served to reinforce the prioritization of product over process, of technical functionality over participatory practice. Engineering studies scholars have previously documented ways in which a 'working technology' is the key determinant of project success, despite a strong focus on processes of design or problem-solving.[18] Boundaries of the engineering discipline were starkly drawn at Smith, where in order for engineers to receive technical elective credit for the Nicaraguan course, the department faculty required their projects to have a significant focus on quantitative analysis or design-and-build. Here disciplinary assumptions about how students move successfully through the engineering curriculum directed student attention toward the product and away from other considerations arguably more important to the project's success as a development intervention.

Whether or not their home institutions imposed such requirements, students in the Nicaraguan course focused primarily on designing the product, even as they worked through the set of interactions among concept, product prototype, and community need. These students tended to move out of the brainstorming phase early, to jump to designing or even building a prototype before other solution strategies had been generated, let alone evaluated. While the course structure returned students to a stepwise process working from idea to prototype, this tendency among the students, combined with a course structure that ultimately

[18]And here "works" means that the object's technical components function as intended, not necessarily that the technology satisfies the targeted need. See Bucciarelli, *Designing Engineers*, Chapter 1, 1994.

asked each team to deliver a single product idea, ran counter to the goals of understanding the product development process and developing robust product concepts connected closely with community needs.

Models of collaboration

A robust type of collaboration was central to this project, both as a challenge to traditional development models that entail one-way transfer of expertise and as a model of education. Collaborations among project faculty and between the project institutions and the general population of Estelí are each considered in turn. Taking faculty collaborations first, a marked gap existed between US and Nicaraguan faculty expectations. Initially, the US faculty hoped that educators from all four institutions would collaborate equally as course instructors, sharing best practices to co-create a curriculum that would draw on everyone's experience and expertise. This degree of collaboration, however, did not occur in practice for several reasons.

First, it became clear that the Nicaraguan faculty were interested in seeing the US curriculum demonstrated, before considering how it (or what parts, if any) might be integrated with their existing curriculum. The Nicaraguan faculty chose to sit in on the course *as students*, and they participated to varying extents on student teams. In a complex negotiation of power relations, the US faculty members' desire for collaboration bumped up against the Nicaraguan faculty members' desire to observe the course as students. It is not clear why the Nicaraguan faculty did not want to participate as curriculum co-developers. The Nicaraguan faculty may have simply desired additional education or professional development and preferred to do this without participating in course instruction. Perhaps the US faculty portrayed themselves too strongly as 'the experts' on teaching this course material, or perhaps an attitude of deference to US expertise reflects post-colonial relations in a more general sense. Additionally the logistics or structural issues around time and communication may have gotten in the way.

Indeed, the logistics of collaboration were in practice quite difficult, as faculty in both countries were unable to maintain communication through regular email and occasional phone calling as envisioned at the planning meeting in December 2006. While the Nicaraguan faculty had access to computers, their schedules as part-time faculty with other full time employment were difficult to coordinate with those of the US faculty. This problem, combined with intermittent electricity service and intermittent computer access in Nicaragua meant that e-mail communication was not reliable enough to communicate as frequently as originally planned, and made scheduling phone conferencing difficult as well. These logistical problems limited participation and contributed to misperceptions about how the collaboration would unfold.

Language barriers also proved to be challenging in consequential ways. For their part, US team members were not accurate self-assessors of their language abilities, and thus some members had assumed greater language proficiency among other team members than actually existed. Interpretation, both by team members and by the Estelí resident, provided some clarity on what was *said*, but there was often disagreement or confusion about what was *meant*. Ultimately reliance on translators or on colleagues' language abilities proved to be no substitute for individual competence in Spanish language and Nicaraguan culture among all team members, as significant nuance and detail was often lost in translation.

In the end the team-taught curriculum was based almost entirely on a course offered in the US,[19] adapted for the setting and condensed to two weeks.[20] The US faculty invited the Nicaraguan faculty to present some information about the Nicaraguan context. To some degree, the inclusion of this unit benefited the US students and faculty more than the Nicaraguan students and represented the kind of extra work host communities often undertake as part of exchange projects. At the same time, however, it is likely that many of the technically-oriented Nicaraguan students were also relatively unfamiliar with the material, which focused primarily on social demographics related to the problems of healthcare, unemployment, and poverty. This limited teaching role did end up showcasing the Nicaraguan faculty's expertise in certain respects, but the Nicaraguan faculty largely remained in the role of student during the course.

The goal of power sharing in the project extended more broadly, at least for some of the US faculty, to include student–faculty and student–student relations. Here, power sharing was attempted through the use of participatory pedagogy and active learning approaches. Despite the wide use of 'pedagogies of liberation'[21] in adult literacy programs in Nicaragua after the 1978–1979 revolution, these techniques have not taken hold in traditional university classrooms. Thus, the Nicaraguan students and faculty were more accustomed to lecture-style courses that emphasize the authority of the professor. An active learning classroom turned out to be a new experience for most Nicaraguan students and faculty alike, something that might have been addressed by the US faculty had they taken more time to introduce the pedagogies employed.

In terms of collaboration between the project institutions and the general population of Estelí, at least two members of the planning team (one Nicaraguan and one US member) held a vision of community collaboration that involved meaningful participation at all levels of the product-development process. At the initial planning meeting, it became evident that the Nicaraguan team member committed to community participation was well-versed in protocols used to facilitate such participation and had experience adapting those protocols to the Estelí context. Thus, the team seemed to support a vision of 'community-based innovation' in which community members would participate in each step of the process, from needs-identification process to brainstorming to concept evaluation to prototype testing (if not development), and then to the evaluation and iteration processes.[22]

Regrettably, but symptomatic of the logistical challenges facing the project, the Nicaraguan faculty member with expertise in community participation did not ultimately participate in the course. In his absence, community involvement morphed into a narrow form of market research, where students first conducted a community

[19]Lane et al., "The Research Game," 2005.

[20]The team was aware that two weeks is not an adequate amount of time, but was limited by, *inter alia*, cost constraints, student schedules, and family responsibilities. Ultimately the team decided to proceed despite time limitations, reflecting an assumption that it would be better to do a project of limited scope than none at all. According to our analysis, however, such decisions require closer examination: Proceeding under such constraints could achieve what goals? Would face what constraints? Would most likely benefit whom? And who would bear what costs?

[21]Freire, *Pedagogy of the Oppressed*, 1970.

[22]This vision was akin to PROJIMO's approach to design by and with users. See Werner, *Nothing About Us Without Us*, 1998.

needs survey, then carried out the brainstorming and idea evaluation without participation of community members, and returned with a second community survey to elicit feedback on final design concepts.[23] This superficial achievement of community participation was due in part to additional structural challenges of time compression and the fact that the course was planned almost exclusively by US faculty participants. The decision to move forward with the project despite absence of the requisite expertise in community participation protocols meant the supposedly central goal of 'community-based innovation' was abandoned *de facto*.

These problems highlight something more fundamental than the logistical challenges of development work, however important such challenges may be in constraining project success. That community participation was superficial over the entire duration of the project calls into question the priorities of the partners in determining what (and whose) involvement was essential to the project and what (and who) could essentially be left out. Absence of community members at the initial meetings where the university collaboration formed further illustrates the problem. At no point in the project was community participation prioritized *in practice* by the larger team. As a result, not only were significant opportunities for working toward social justice lost but also the likelihood of *creating social injustice* increased. Moreover, because this was a learning exercise, students likely came away with a distorted sense of the potential value of community participation in such a project, thereby reproducing the de-prioritization of community involvement in technology-based development more generally.

Economic structures

Helping students understand the economic framework in which a given entrepreneurial initiative operates is an essential element of the product innovation curriculum, even if that economic framework is often assumed rather than explicitly taught. In international exchange projects, political and cultural differences complicate the role played by underlying economic frameworks, especially when they are not made explicit. Even when explicit, product innovation instruction rarely asks students to face the constraints and opportunities of local economic conditions *as situated within* neoliberal[24] economic policies with global reach.[25]

The Nicaragua project faced these complexities directly in one noteworthy set of exchanges. In adapting the US-taught course to the Nicaraguan context, one team member proposed an exercise in which teams would receive about 20 US dollars (which translates to 400 *Cordobas* in currency exchange, but represents

[23]And because the engineering faculty participants were not well trained in human-subjects research and Institutional Review Board protocols, the logistical challenges of conducting such a survey imposed more of a barrier than they would have for faculty members more experienced with human-subjects research projects.

[24]Neoliberalism is an economic philosophy characterized by reliance on the free market and a corresponding reduction of social services and governmental protections related to labor and the environment. In global development contexts, neoliberal policies implemented by the World Bank and International Monetary Fund increased debt burdens on developing countries while restricting their spending on education, health care, environmental and labor protections, etc. See Steger, *Globalization*, 2003; and Harvey, *A Brief History of Neoliberalism*, 2005.

[25]Riley, "Resisting Neoliberalism in Global Development Engineering," 2007.

approximately a week's wages for a day laborer in Estelí). This money was to be used by student teams to set up a local business in the town, run it for a week, and see how much money could be made. The general experience with this exercise in US classes is that students are surprised at how much money they can make, for example by selling cookies or t-shirts or other home-made goods.

The proposal to transfer this educational experience without adapting it to the local cultural context (apart from calculating currency exchange) created significant conflict among the US faculty in the project. Some felt that the amount of money was excessive in terms of local buying power. Some were concerned about how student businesses, which would essentially amount to street vending, would compete with local street vendors who rely on such work as their primary source of income. Some were troubled by how it would read culturally for US students (and relatively economically privileged Nicaraguan university students) to be taking on the role of a street vendor. And others believed these potential negative consequences were unlikely.

The major point of contention, however, involved whether the proposal rested on reasonable assumptions, namely that what works under consumer capitalism in the US, where a high percentage of consumers have disposable income, was appropriate to the much poorer Nicaraguan context. Given the uncertainty, opponents of the proposal further argued that it was inappropriate to engage in trial-and-error experimentation in a local economy without addressing that economy's structure or its relationship to broader economic forces.

In the end, faculty disagreement led to shelving the proposal, and students engaged in a very different exercise to familiarize themselves with the local economy and potential opportunities for entrepreneurship, one that would also stimulate thinking about global competition. In an import-analysis exercise, students went to local stores and identified which products were manufactured domestically and which were imported into Nicaragua. The goal of this exercise was to identify items that could be manufactured locally and at lower cost than imported goods, allowing students to place their project in the context of contemporary global economic policy. Since the conditions of development assistance loans to Nicaragua require open markets, cheap imported goods are readily available on the shelves. Any local entrepreneurial project, if it is to succeed, must effectively compete in the environment of global trade. In addition to directing attention to the global economic context, the import-analysis exercise also highlighted for the students how many of Nicaragua's goods are imported, pointing to a wider array of opportunities for local production.

The issue of creating entrepreneurial strategies that fit within Nicaragua's political economy was not fully discussed among the project's collaborating faculty. Nicaragua's experience of devastating wars and natural disasters over the past 30 years, combined with neoliberal economic policies that increased the country's debt while restricting government support for local industry, have made it the second poorest country in the Western Hemisphere and created significant challenges to economic regeneration.[26] Failure to accommodate such realities is sure to doom a development intervention, especially so if it is founded on product innovation and entrepreneurship in the local economy.

[26]Kendrick, "How the US Continues to Manipulate Nicaragua's Economic and Political Future," 2006.

In what may have seemed to be a contradiction, entrepreneurship and small business development was viewed as a reasonable strategy to achieve local economic empowerment despite that Nicaragua is a country that sought to depart from a free-market capitalist economic system. In a context where it is not unusual to see co-operatives succeeding alongside individually owned private business, simply assuming the superiority of the latter model – or worse, not even realizing there is an option – is indicative of how contextual differences are misunderstood in project development. More interesting, however, is the fact that this difference could go more or less without discussion among collaborators throughout the entire course of the project. Perhaps the product orientation of project participants crowded out other, potentially more viable alternative project foci: modeling marketing, sales, or distribution of the product, for example, or prototyping a business venture instead of just the product it might sell. Perhaps better collaboration would have resulted in some of these areas being more fully explored; it is worth noting that there was considerable Nicaraguan faculty expertise in these areas. It was surely a missed opportunity for the US team members not to explore these aspects, though perhaps the Nicaraguan faculty felt it was familiar ground.

In this case, despite good intentions and in some instances conscious effort to the contrary, product won out over process, communications broke down, and the team lost sight of larger economic and political contexts in which product development is carried out. Critical opportunities were missed for reducing social injustices and, worse, problematic power relationships and resulting social injustices were reinforced.

Appropriate technology in Sri Lanka

The second case of engineering for development that we consider involves the work of a Sri Lankan NGO called the Energy Forum. Based in Colombo, the country's largest city and its financial and commercial center, the Energy Forum promotes and implements renewable energy technologies across the island nation. Though a small organization, with a permanent staff of between four and six members, the Energy Forum carries out an impressive diversity of activities and is well regarded by most, but not all, actors in Sri Lanka's 'energy and development' sector. For 11 months spread over the years 2000–2002, one of the authors (Nieusma) was a participant-observer in Sri Lanka's renewable energy community, working especially closely with the Energy Forum and the organizations, individuals, and rural communities with which it collaborated.[27]

The Energy Forum's two-pronged approach to development is closely aligned with that of the international NGO, Practical Action, whose South Asia regional

[27]Nieusma's work in Sri Lanka included participation in much of the Energy Forum's internal organizational activities as well as a variety of energy-sector activities, often along with members of the Energy Forum and occasionally as an independent researcher. Nieusma also interviewed several dozen participants across the sector, providing a sense of where general consensus existed and where there was contention regarding development policy and approaches. (See Nieusma, "The Energy Forum of Sri Lanka," 2004b for a more detailed account of this case data.) While the following insights have been distilled from this experience, the goal here is not to summarize the "Sri Lanka position" but is instead to extract lessons relevant to the larger themes of the paper.

office is also located in Colombo.[28] The first prong involves promoting a particular set of appropriate technologies, in this case renewable, decentralized energy technologies – solar photovoltaic and solar thermal, community-scale hydro and wind, biogas and high-efficiency cookstoves, and most recently dendro power (wood-fueled electricity generation). Across Sri Lanka's renewable energy sector, including in the work of the Energy Forum, engineers play a central role in promoting, designing, and implementing renewable energy technologies as well as in setting Sri Lanka's national and regional energy policies.[29] In the context of national energy policy, renewables are seen by promoters as critical to the nation's energy (and hence financial) independence, and so engineers are joined by development experts of all stripes, including policy analysts, finance experts, and environmental and community advocates among others. Especially in the energy sector, however, engineers enjoy high status in Sri Lanka, well above that of experts in finance, community organizing, or policy making.[30]

The second prong of the Energy Forum's development approach centers on rural electrification, that is bringing electricity to the roughly half of Sri Lanka's population that lives 'off-grid' , that is, beyond the reach of the national electricity grid. Here, members of the Energy Forum (and others) see new technology implementation as playing a central role in achieving rural electrification, but the main motivation is one of social justice: How to more fairly distribute the nation's energy resources – to extend the nation's energy infrastructure – so that the rural poor will benefit as well. Not surprisingly, engineers are again central players in the Energy Forum's rural electrification initiatives, but they work in close collaboration (and sometimes tension) with others, finance and community development experts in particular. In fact, negotiating the terrain of technology-centered development is at the core of the Energy Forum's approach and is manifest in the organization's very configuration. With an electrical engineer serving as the organization's coordinator (the head of staff), and a community organizer serving as the second in command, and with a board of directors representing all stripes of development expertise, the Energy Forum itself embodies the range of collaborating and competing domains of expertise active in Sri Lanka's overall energy and development sector.

As part of its two-pronged approach to development, the Energy Forum carries out diverse activities, ranging from energy education campaigns to implementation of renewable energy systems and from energy policy consultation to serving as a network hub for Sri Lanka's entire renewable energy community. Its work includes considerable time spent in rural villages as well as regular meetings in Colombo with government functionaries and local and international development assistance workers from organizations like the United Nations Development Programme and the World Bank. The reflections that follow draw on the full range of these activities, but the case data focuses particularly on one of the Energy Forum's rural

[28]ITDG-South Asia (as Practical Action was called at the time) played a leadership role in forming the Energy Forum as an independent organization in the mid-1990s.

[29]The Energy Forum had three engineers (one electrical and two mechanical), a community organizer, a former journalist, and two administrative support staff during the research period. Several additional engineers (among others) were represented on the organization's board of directors, two of whom worked closely with the staff on a regular basis.

[30]See Nieusma, "Challenging Knowledge Hierarchies to Achieve Sustainable Development in Sri Lanka," 2007 for a review of how different expert knowledge domains were negotiated across Sri Lanka's energy and development sector.

electrification initiatives, namely a dendro power development project for a rural village (with a population of about 1400) in the south western district of Monaragala. This project would use locally grown fuel wood to produce a modest amount of electricity for the village. Although the project ended up being aborted several months into implementation, by that time the Energy Forum had completed detailed project planning, preliminary project implementation within the village, and initial technology systems design, thereby providing adequate material to analyze here.[31]

In Sri Lanka at the time, there was considerable enthusiasm for dendro technology, both within the renewable energy sector and beyond it. Relatively new to the scene, dendro offered entirely new possibilities for energy and development sector. According to its advocates, dendro offered the possibility of energy independence – at least as far as electricity was concerned – as mentioned above. Since the feedstock can be locally grown and processed, potentially requiring no outside resources beyond the power plant itself and the know-how to get the system up and running, dendro plants can produce home-grown electricity, literally. The technology is relatively inexpensive (given external development assistance – the Energy Forum's project was estimated to cost $40,000), with a relatively straightforward power plant and standard electricity distribution infrastructure. It has also been proven to work reliably in various settings (not including rural villages, at least at the time of the research), and can be scaled for the modest energy requirements of small rural communities. Finally, it can be implemented in remote locations unsuitable for small-scale water or wind-powered systems.

For the Energy Forum, however, electrification was only a means, not an end. Ultimately, the Energy Forum's commitment to rural electrification reflected a desire to provide the infrastructure needed for sustained social and economic development within rural villages. Beyond simply growing fuel wood and then processing and burning it for electricity, the dendro project was seen by the Energy Forum as an opportunity to build organizational capacity within the community (that would manage the system) and for community members to initiate a range of economic activities that were not possible without electrification. From the Energy Forum's perspective, the intervention included but extended far beyond installing the technological infrastructure – the dendro power plant and electricity distribution system. Well before the organization initiated detailed system design, it studied the resource base in the community, nurtured effective working relationships with village leadership and community members, executed two participatory design workshops where villagers shared their perspectives on the project, and assessed long-term project viability in terms of organizational, financial, agricultural, and technological capacity within the village.

The Energy Forum's activities surrounding the project illustrate well the challenges and opportunities of engineering for development in the Sri Lanka case. Despite the existence of considerable logistical barriers, the overarching challenges to technology-centered development in this case went far deeper. How much can technology achieve in terms of broader development goals? What does

[31]The dendro project was aborted because the Energy Forum learned, despite prior confirmation from authorities of the contrary, that the national electricity grid was scheduled to be extended into their target village in the near future, which would make redundant their electrification scheme.

long-term sustainability mean in the context of development, where development workers sweep in and out of a local context in a relatively short time (whether it be a few weeks, months, or even years)? How can outsiders best come to understand local people's priorities and thereby help to improve their living conditions? Beyond these questions, this case also highlights the need to closely interrogate the engineering-for-development model itself, apart from the range of particular barriers such projects face. It shows that achieving social justice in the context of engineering-for-development work is difficult even with situated cultural awareness, inter-organizational alignment, and a diverse, highly experienced expert workforce.

Prioritizing technical functionality

As in the Nicaragua case, members of the Energy Forum approached their work recognizing that technology implementation alone was not sufficient to achieve their goals. While they frequently stated that electrification, by itself, was desirable – even without, for example, income generation or measurable improvements in student academic achievement – they also recognized that failure to attend to a broader set of factors would result in a short-lived electrification scheme. In particular, they articulated the need for careful attention to community capacity building: educating electricity consumers on what types of appliances would not be allowed, training plant operators on operations and maintenance, creating organizational procedures for troubleshooting and conflict resolution in advance of system breakdown. Distinct from social justice goals, all these were required simply to ensure the technology remained functional over time.

Yet the Energy Forum also had higher expectations of the dendro project, extending far beyond provision of electricity and the support activities that that demanded. With electricity newly available, why not devise specific income generation activities? Why not combine electrification with educational programs and assessment mechanisms to help ensure students studied more (i.e. after dark)? In other words, in the language of development assistance agencies, why not facilitate 'productive activities' surrounding electricity use? Instead of focusing exclusively on providing electricity, the Energy Forum sought to incorporate a range of social, organizational, and economic goals. In their own words, they pursued an 'integrated approach' to development for this project.

The Energy Forum's attention to project facets beyond the technology was evident in the limited role played by technical expertise early on in project framing. Well before any technical design work took place, for example, there were project site visits to assess conditions 'on the ground' in the community: material conditions, local geography, key stakeholders, community members' willingness and ability to participate, local politics and whether factions existed among various sub-groups, etc. Even before moving forward with a formal proposal for funding, the Energy Forum sought to ensure the target community was prepared and able to absorb the responsibility of the project.[32] The systematic application of technical expertise to

[32]If community members could not afford to take time away from farming or paid labor, for instance, this would not be considered as a candidate site for implementation. This situation – where the "poorest of the poor" are not considered as candidates for certain development projects – represents a structural injustice, certainly. But this does not imply that the development organizations' practice is also unjust. In fact, it more accurately represents the

the dendro project commenced only after firmly establishing a match between the project requirements and its targeted implementation site.

As compared to the Nicaragua case, many of the forces that might otherwise have led to a focus on product over process were effectively eliminated in the dendro project. First and foremost, the expertise available to the Energy Forum was both diverse and locally situated. Engineering expertise was complemented with a sociologist and two community organizers. All participants were fluent in Sinhalese, the language of the village, and all had extensive experience working in similar settings. Second, there were no obvious competing requirements for the participants in carrying out the project, delimiting what activities 'counted': There were no formal educational requirements and there were no professional/disciplinary boundary monitors to say 'that's not sufficiently technical to count as engineering.' All of the engineers participating in the project understood the centrality of non-technical factors in determining the success of the project, both as a functioning electrification system and as a broader integrated development intervention.

Yet despite their attention to context and their local knowledge, despite the balance of expertise and integrated approach to development, technical functionality still ended up playing a defining role in the dendro project planning. Part of the reason for this was entirely sensible: a failed dendro power plant or a failed distribution system would doom the entire intervention. However sensible income generating activities, for example, might otherwise be, they would be meaningless without the production of electricity that they were designed to leverage. A functioning electricity system was a pre-requisite for project success.

Other reasons for the centrality of technical functionality in this project, however, were more questionable, at least in terms of the immediate interests of intended beneficiaries. Dendro technology was newly popular in Sri Lanka at the time, offering the latest round of promises for energy independence, rural empowerment, financial expansion, etc. This meant that funding agencies, implementing NGOs, and even some private-sector organizations were all racing to establish themselves as Sri Lanka's dendro experts. To be the first to succeed with the new technology promised returns on investment reaching far beyond those garnered by intended beneficiary communities. The Energy Forum sought to become Sri Lanka's authority in off-grid applications of dendro power in particular, and so proving the technology (and the organization's ability to successfully implement it) was an ulterior motive of the project. The stakes of proving the technology were so high, in fact, that the dendro team strategized moving forward with the project even after learning that the national grid was to be extended into their target village in the near future.[33] The promise of dendro technology itself was seductive even to

wisdom of development organizations with limited resources and their own focused missions. First of all, project success when working with the most destitute was close to zero, so the potential positive impact on these communities was minimal. More importantly, the potential *negative impact* of poor people investing in a project that ended up failing was eliminated. Secondly, it is arguably government's responsibility, not that of NGOs, to provide its citizens broad safety nets – at least insofar as possible in various settings.

[33]To be fair, other forces also pressured the Energy Forum to continue on with the project, not the least of which was the tremendous investment already made that otherwise would have become wasted. And the Energy Forum leadership ultimately dropped the plan, despite these forces.

members of the Energy Forum, who were otherwise skeptical of technology-led development initiatives.

The high status of technical expertise in Sri Lanka generally also impacted the unfolding of the dendro project. Even though all the engineers participating on the dendro team understood the centrality of non-technical project components for a successful outcome, and even though they were reluctant to define the intervention as technology-driven, it was the technology (and the dendro power plant in particular) that was featured in all of the group's external communications surrounding the project (except within the host village), especially to international funding agencies. The Energy Forum's quest to become the 'go to' organization for off-grid dendro was grounded not only in the potential revenue streams that would become available once the technology was proven but also in a desire to highlight the organization's engineering competence. The organization had engineers on staff and within the board of directors, but from the outside, the Energy Forum was widely considered to be more expert in rural community participation than in technology implementation, which had much higher status. The World Bank, for example, directed more of its funds to a competing (for-profit) renewable energy technology consultancy, justifying its decision in part on the grounds of their greater technical expertise. The Energy Forum leadership saw the dendro project as an opportunity to prove their technical engineering merit even as they understood this was less important when collaborating with the target community.

Project ownership

As with its parent organization, the Energy Forum's engineering for development work revolves around a version of 'appropriate technology,' but the conceptual and semantic tangle of defining 'appropriateness' has been replaced with a more straightforward focus on *control*. As stated on their website, 'Practical Action has a unique approach to development – we don't start with technology, but with people. The tools may be simple or sophisticated – but to provide long-term, appropriate and practical answers, they must be firmly in the hands of local people: people who shape technology and control it for themselves.'[34] With this approach, many different technologies might be appropriate to a given context, as long as they are under the control of intended beneficiaries. The shift in focus from 'appropriateness' to 'control' makes sense in light of changes in development practice over the past few decades, and particularly in light of globalization. And the question of having control over development project decision making is central to the Energy Forum's vision of social justice in development. However, what is meant by 'control' in the Sri Lanka context, and how it is manifest in practice, deserves elaboration.

In Sri Lanka, the issue of control is typically spoken of in terms of project 'ownership,' which came up repeatedly surrounding the dendro project (as it does frequently across the sector). Despite seeming agreement on the importance of *community* ownership by most development workers in Sri Lanka, there is a wide spectrum of associated expectations. On one end of this spectrum, ownership implies only that community members *actively support the project* – to believe in its value and to take responsibility for the project's success. Real control by community members over project decision making is not necessarily a component of this version

[34]Practical Action, "About Us," 2009.

of ownership, which was widely prevalent in Sri Lanka, especially among the most powerful development organizations (the most noteworthy example of which was the World Bank). On the other end of the spectrum is a more literal application of the term, or as the Energy Forum put it 'genuine community ownership'. This entailed the ability to determine project priorities *from the beginning* and to control *all facets of decision making* surrounding a project, at least as they are manifest in the local context.

The Energy Forum members were not naïve regarding their control over the dendro project: they conceived it, planned it, implemented it, and managed it. Rarely would one find a development project in Sri Lanka actually solicited by, managed by, or implemented by beneficiary community members themselves (though some such experiments were successful, particularly in micro finance). Beyond merely touting a commitment to community ownership in the dendro project, the Energy Forum actively and systematically reflected on the matter of 'transferring control' to the community over time. In order to arrive at a position where transferring control was even possible, however, the Energy Forum owned all aspects of the project in its initial phases. The Energy Forum knew it needed first to understand the context[35] and second to become trusted by the local community members if any degree of 'community ownership' was to be arrived at.

To provide a base of mutual understanding, the Energy Forum's early visits to the target village included activities to learn about the local terrain, both physical and social/political. It also worked closely with regional development workers who were knowledgeable about the village and the surrounding area. It cultivated the support of regional politicians, met with regional electricity systems planners, and enrolled the 'village leader' to act as liaison with the rest of the villagers. Only after this groundwork was laid did the Energy Forum commence community workshops, the first two of which were dedicated to gauging the community members' interest and willingness to support and otherwise invest in the project. The community members' development priorities were assessed, as were their material resource base and their skills. Technical skills were particularly important, since transferring control meant that someone within the community would ultimately manage the dendro power plant and the electrical distribution system. The community members were then introduced to the capabilities, as well as the limitations, of the proposed dendro electrification scheme before a decision to move forward was voted on and discussed.[36]

In terms of project ownership, all of these activities were fully and for the most part intentionally 'controlled' by the Energy Forum, even as it sought to create a space for discussing the project that was both open and frank. The Energy Forum was not 'for hire' by the local community, and the community members were in no position to make informed decisions about the project before being introduced to it.

[35]What it means to "understand" the local context is, of course, highly variable. Rather than getting into the conceptual morass of "understanding difference," this analysis takes an indirect approach: Understanding comes through investing both *time* in a community and a *systematic effort* to learn about it.

[36]One critically important limitation was that each household would be allowed roughly 100 watts of electricity during plant operation, far less that what would be available with a connection to the national grid. The relatively low wattage allotment of community power schemes, such as dendro, precludes the use of popular high-energy appliances like refrigerators and immersion water heaters.

The Energy Forum's introduction was carefully crafted to enlist support at the same time as it made clear the nature of the investment required on the part of community members. As part of enlisting support, the Energy Forum's coordinator also reminded participants that the project, like many similar projects, was to an important extent an experiment – that there were risks of project failure even after investments were made. The Energy Forum needed community support for the dendro project to proceed, but sought not to mislead community members as to what it was they could provide.

The community assessment workshop was only the first phase in a series of activities designed to incrementally transfer control of the project to villagers, but the project was aborted before the following phases were implemented. The next planned phase of the project was a series of capacity building activities, where villagers would be systematically trained on all facets of the project – agriculture, power plant operations and management, financial management, conflict resolution, etc. Only after training of community members was infrastructure implementation to commence, and this too was to be carried out with the active participation of the villagers. After getting the system operational, a two-year monitoring and evaluation phase was planned (and budgeted) to ensure the Energy Forum would be available to the community as inevitable complications arose over time.

The Energy Forum's vision of community ownership of development projects took seriously the challenges of enrolling support within a local community for externally motivated activities. These motivations included transferring control to villagers (with a detailed plan for so doing built into the overall project), but the Energy Forum knew that serious barriers to villager empowerment remained. To say that the Energy Forum was concerned with matters of control is not to say that the transfer was something that came easily, even given the detailed planning that went into it.

Social power in development assistance

The Energy Forum's efforts to transfer control of the dendro project to the local community were praiseworthy, certainly, and perhaps a model that other development project planners should strive to emulate. However, the Energy Forum's approach, at least in the project's early stages, also fits comfortably with a deficiency model of development, where the problem of development is understood to be rooted in deficiencies among the target community – a lagging behind – rather than being rooted in the broader cultural and economic systems that place rural farming communities at the bottom of vast pyramids of food production.[37] In the case of the dendro project, those deficiencies were infrastructural, knowledge and skills-based, organizational, and financial. The Energy Forum sought to provide each of the most important missing ingredients – electricity, technical skills, organizational structures, income-generation opportunities – so that intended beneficiaries could better provide for themselves over the long term. And yet the Energy Forum's leadership understood the contradiction inherent in their activities: intended beneficiary communities were compelled, to a non-trivial degree, to 'own' projects motivated by external groups with a distinct set of interests.

[37]See, e.g., Rist, *The History of Development*, Chapter 4, 1997.

The dendro project highlights the complicated relationship between the project sponsor – the Energy Forum – and the host community, even as it exemplifies a relatively sophisticated and highly reflective approach to development. Regardless of the purity of its motives and regardless of the effort put into transferring control in a sensible way, the Energy Forum maintained authority over the villagers, at least concerning the project, at all times. It was the Energy Forum, after all, that initially decided to pursue the project and that ultimately decided to terminate it. This authority derived partly from the fact that the Energy Forum brought in the resources to make the project possible and partly from the elite status enjoyed by development workers relative to aid recipients generally. That the Energy Forum controlled the resource flow is unremarkable, even if significant when discussing power relations; the status differential between development aid givers and receivers, on the other hand, deserves further consideration.

The elite status of the dendro project team members undermined their efforts to empower community members in the targeted village. Most notably, the communication between the groups was not as open as the Energy Forum wished – too many community members were reluctant to share their thoughts or to contradict the project sponsors. And some of the dendro team members had a difficult time suspending their own assumptions and associated judgments about the needs of the villagers. As suggested by the Energy Forum coordinator, the team went to the village already knowing that electricity 'was needed,' making it difficult to hear what the villagers were saying about, for instance, their problems with alcohol or joblessness. These problems were translated by the Energy Forum team, with little effort, to problems amenable to the dendro project. The communication process was further hampered by villagers (reasonably) attempting to strategically maneuver within the development-aid system: as suggested by the Energy Forum coordinator again, in the community participation workshop the villagers responded to questions about their needs fully knowing that an electrification project was what was on offer. Regardless of their assessment of the project's merit, the villagers were not in a position to turn aid away, even if it failed to align directly with their own sense of their immediate development problems.

In discussing development assistance more generally, a project manager at ITDG raised the issue of social power differentials and how they complicate communication. He stated that a core lesson from his experience was the challenge of outsiders learning about the local context, emphasizing not only the need for learning from locals but also its pre-requisite: 'unlearning'. As he put it,

> If I go to a village, and from the beginning they learn that [I am] coming from a university, they don't talk. They don't share their experience or traditional knowledge. They think, 'You are much more knowledgeable than us, so why should I talk rubbish?' Right? So therefore you must have a special kind of technique to unlearn your [assumptions] and learn from these people first.

His unlearning technique referred less to a set of specific steps one must take and more to a posture of mutual inquiry, which takes seriously the vast gap between one's own presumptions and villagers' understandings of their needs, priorities, and abilities.

The ITDG manager went on to clarify that taking these differences seriously does not necessarily mean deferring to villagers in every instance.

> It's not to say that what they're saying is 100 percent correct. But to understand their perception, to understand why they are doing things like that, right?, before you tell them do it like this. And even in the dialogue, you have to ask more questions, for example why, what, when. Rather than my preaching to them, look, go follow this plan this way.... If I learn from them how they have been doing something and why they are doing it like that, I come [to learn] their ideas, which I didn't know. And if they're doing something wrong, then I can have the freedom of dialogue to correct them as well.

According to this logic, the development expert has the responsibility to listen to villagers on their own terms, as best as possible, but, at the end of the day, the development expert retains control over the process: The expert reserves the right to 'correct' villagers where appropriate.

The Energy Forum recognized that establishing the level of trust necessary for open dialog across power differentials required relationships built over time and the ability to listen both patiently and critically. It required establishing a collaborative environment based in mutual understanding from the start. This surely demanded not assuming one's technical credentials should override local knowledge, but it also highlighted the power development workers held over beneficiaries generally – based in education, class, project decision-making authority, the history of colonialism, etc. Problems arising from this power differential could be mitigated, but the unequal power relationship could not be denied.

Engineering, globalization, and social justice

By applying social justice as an analytic lens to the above cases, we seek to understand what is entailed in moving beyond the 'voluntourism' model of student learning[38] evident in the Nicaragua case and the 'deficiency' model of development evident in both cases. In the following sections, we argue that engineering for development projects risk (1) over-focusing on technology – whether product or infrastructure – in ways that both (2) occlude power imbalances in social interactions and (3) ignore larger structural issues that limit opportunities for sustained improvements in social justice. In so doing, we seek to move toward a place of critical engagement with the enduring political and economic structures – as well as the structures of thought – that facilitate and maintain vast global inequities.

Over-attending to technology

For engineers and other development workers concerned primarily with technology-oriented development projects, the question of control over decision making quickly becomes a question of expertise: Who has adequate expertise to determine how technology-centered development projects are conceived and executed? This question is made more difficult when, as all participants seem to agree, the project's underlying technology must 'work' at the end of the day. Given that functionality is critical, and given that this dimension of such projects is the most straightforward to assess, it becomes all too easy for technical expertise to overrule other development inputs – both other domains of expertise and other perspectives more generally.

[38]Simpson, "'Doing Development,"' 2004.

Both cases show evidence of working against this tendency, but with only partial success.

Structures of funding and recognition in both the academy and the marketplace (including the market that is international development assistance) reward over-attending to technology and undervalue cross-disciplinary work. The dominant narrative in engineering, in part to recruit and retain engineering students, casts technology as progress in absolute terms,[39] and technical skills are what define engineers as individual practitioners and the profession as a whole. In line with that, the dominant assumptions held by the larger development community are that engineers lack exposure to other languages and cultures, ways of knowing in the social sciences and humanities, and knowledge of development historically and in the present day.[40] Thus engineers are signaled from many directions that they are not accountable for shortcomings in their own education or experience in this regard, and they need not acknowledge the importance of various other kinds of expertise if the project at hand is primarily an engineering one.

The imperative to make the technology work also manifests in under-attending to matters of process. Both of the case studies highlight the importance of process and the ways in which the culture of engineering, the structure of academia, and the politics and economics of development create a push toward successful outcomes – where success is defined narrowly in terms of systems functionality, without regard to improvements in the overall quality of life or whether 'development' is achieved in other terms. Attention to process will not prevent all failures or guarantee socially just outcomes, though there are certainly cases where better processes would have led to better outcomes. Rather a focus on process that anticipates a high failure rate and plans accordingly can mitigate the consequences of that failure in the community and provide adequate compensation.

In both the Sri Lanka and Nicaragua cases, balancing engineering expertise with 'social' expertise mitigated over-attendance to technology in certain respects. However, the tendency to lump all social science and humanities experts into one group evidences how easy it is for engineers to form real gaps in engineering-for-development projects.[41] In the Nicaragua case, involving a development economist and Latin Americanist fluent in Spanish re-directed the team's focus to process, cross-cultural communication, and global economic contexts at times, even though technical expertise was still prioritized throughout the project. In the Sri Lanka case, attention to balancing engineering expertise at each stage of the dendro project, but particularly in early stages of project framing and community interaction, meant that the project was considerably lengthened (and its costs increased) compared to an infrastructure-only project. Further, it meant that time and effort were invested in activities that would not necessarily pay off in terms of the Energy Forum's status in Sri Lanka's energy and development sector.

[39]Marx, "Does Improved Technology Mean Progress?," 1987.

[40]Hammer, "Why Projects Fail," 1994 reviews a range of causes of development project failures, many of which overlap with the types of skills engineers have often been criticized for lacking: communication, listening, interpretation of cultural differences, understanding of social power relations, etc.

[41]And the same holds true for lumping all technical experts together under the term "engineer" for projects of considerable technical complexity.

Occluding social power imbalances

The case studies also highlight the complexities of working across differences of class, culture, language, education, political power, and economic privilege. In an eagerness to 'empower' local communities through development work, real power imbalances tend to be glossed over. The fact that development workers are in control of their projects, especially in the early phases, needs to be acknowledged even as efforts are made to transfer control. In almost every case, development projects entail an 'awareness-raising' component to educate intended-beneficiary communities on what is being offered and why they should want it. This awareness raising can be more or less manipulative – entailing respectively less or more open dialog and questioning by beneficiaries. Nevertheless, the fact that development interventions are initiated outside of the beneficiary community means that, if intended beneficiaries are to participate at all, there must be a phase for bringing them up to speed with the project plan. And this is necessarily done on the terms of the project initiators.

The legacy of colonialism and a one-way technology transfer model linger, and an unlearning process is required of all participants to become conscious of those relationships – to make them explicit – in order to counter their persistence. When representatives of economically rich countries bring (impose) a new model – even if it is a power-sharing model – there is the potential to recreate colonial power relations in the process. When intended beneficiary communities defer to outside experts, especially when those experts have little knowledge of the local context, they too participate in recreating colonial relationships.[42] But regardless of the degree to which host communities participate in development projects – 'willingly' or not – outsiders have special responsibility in managing the power relationship with intended beneficiaries, first because they are the project initiators and second because of the relatively privileged position they hold as 'experts'.

This is as true of relationships between local development workers (experts) and intended beneficiary community members as it is between international exchange participants and host communities. In fact, there is what might be called 'infinite regress of the local' – where increasingly smaller 'communities' can be identified as 'local'. Analysts and development workers alike must be careful not to characterize an entire community or group in a way that represents only part. From the perspective of the (international) World Bank, for example, both the Sri Lanka NGOs and the rural villages in which they worked were 'local,' and yet in many respects there was greater difference between these communities than there was between the World Bank employees and the 'local' NGO workers. A similar pattern existed in Nicaragua. In the case of engineering-for-development work, engineers who collapse these differences in order to move forward in design risk perpetuating injustice at one level while trying to reduce it at another level.

Foreign language skills, and more generally cross-cultural communication, are a key area for understanding 'accountabilities in tension'. There is a responsibility for development exchange workers to continually improve their individual language skills and, where fluency does not exist, to involve a language expert in a central way.

[42]It is essential to note that 'relatively less powerful' host communities are not wholly without power; they have power and they exercise it in ways that substantially shape development projects, sometimes in concert with a given project's goals, sometimes against them.

Language study remains omitted from most engineering educational programs in the US and few engineering curricula prioritize it. Similarly, host-language fluency is rarely required of international engineering development exchange programs.[43] It is important to ask what an 'ethical level of language competency' is for individuals working on international development projects. When language is viewed merely as a logistical concern rather than a critical site of power relations, the consequences for process, project, and social justice are likely to be considerable.[44]

Attending to power relations in an educational model of development raises questions about the present day service-learning model; as the Nicaragua case shows, the tensions between service and learning are problematic for communities and learners alike. According to a Practical Action director in Sri Lanka, student exchanges in development assistance should be undertaken primarily as a *learning* activity and only secondarily as a *service* activity. What relatively inexperienced engineering students have to offer development projects – namely a few years' engineering school course experience and their physical labor – is modest and, generally, readily available (regionally if not locally)[45] and more affordable (at least relative to the budgets of typical international student exchange programs). One suggested alternative that shifts power relations considerably is the idea of 'development training camps' in which locally-embedded organizations provide intensive workshops on the local culture, identify an appropriate development initiative in that context, and structure student activity around such initiatives.[46] Students would be put in the role of learner first and only after coming to identify the limitations of what they understand of that context would they be placed in a local community to 'serve'. In addition to greater structure and better management of resources, such programs could address shortcomings of the two or three-week timeframe bounding most development projects carried out by exchange students. Since any thoughtful reflection on development assistance recognizes that real change takes years, even decades, not weeks of assistance, plugging into existing projects managed by local organizations has far more potential to contribute to real change.[47]

Again, actions that stem from an analysis of power are not guaranteed to be more socially just, but at least a process is put in place to identify injustice at its roots and work toward socially just ends. Attention to social power relations among development workers from various contexts and between development workers and intended beneficiaries also paves the way for looking at broader forces impacting development outcomes.

[43]English-only engineers could work exclusively in communities where English is commonly spoken, or at least where key partners are English-speakers. But this creates a tendency to help only where convenient, which has its own problems (see note 32 above).
[44]Cooke, ''Rules of Thumb for Participatory Change Agents,'' 2004.
[45]Sri Lanka is not representative of all developing contexts, of course, but it is reasonable to generalize that – compared to international students at least – ''more qualified'' and ''more local'' engineers are usually available.
[46]This idea was proposed by a staff member of Practical Action-South Asia.
[47]It is important to note here that, in the spirit of our overarching analysis, one should not assume any given local organization is either interested in providing learning experiences for international exchange students or equipped to undertake such an endeavor. In the interest of empowering local organizations, it should be they who determine how, or whether, such exchanges are carried out.

Ignoring structural forces

The rise in interest in engineering for development coincides with neoliberal economic policies in an era of globalization. As a political and economic phenomenon, globalization has been driven primarily by wealthy nations that are sure to protect their own financial interests first.[48] As the structural conditions of international development assistance loans require nations to divest from funding social services and infrastructure projects at home and force open their markets to international competition, engineers from wealthy nations are stepping in to help impoverished communities meet basic needs. When there is lack of acknowledgement that the needs themselves are often made more acute by economic policies driven by wealthy nations' interests, the likelihood increases of defining the problem in a narrow and limited way that precludes getting at the root of the problem of global economic injustice. It also leads to an understanding of such needs as static, such that a solution designed at one point-in-time will be relevant to the problem as it evolves into the future. By looking more deeply into the structural causes of global and regional poverty (as well as ecological decline), social justice advocates of all stripes might find that what is a 'given' today in many communities is likely to be a design goal for future design teams.[49] Rather than coming in with assumptions about the potential of development to declare 'the end of poverty'[50] or seeking to create a 'fortune at the bottom of the pyramid,'[51] global economic structures need to be critically confronted. Most importantly, this means carefully assessing how a particular technological intervention will put intended beneficiaries at the mercy of broader economic and cultural forces that are beyond their ability to influence. By making local communities more vulnerable overall or by failing to situate interventions carefully within the larger economic picture, engineers may be unwittingly facilitating social injustices by solving the right problem but at the wrong level.

Another facet of globalization is how technology dissemination through development projects leads to unanticipated outcomes that are detrimental to many communities. Development interventions always occur in a relatively compressed timeframe whether implemented by exchange volunteers or in-country development workers. Social mechanisms that provide for basic needs evolve over much longer timeframes, and hence have a degree of stability (even if at a 'lower level' of provision). When technologies fail, vulnerable populations that have become dependent on them tend to suffer the most. For development projects that are initially successful, that success may facilitate the dismantling of social networks.[52] As a result, if the project fails down the road, community members will be more exposed to risk. Perhaps ironically, development projects that are total

[48]See Steger, *Globalization*, 2003; and Harvey, *A Brief History of Neoliberalism*, 2005.
[49]Taking water provision as an example, the engineering approaches of adding access points (e.g., wells) or providing water cleaning technologies (for unhygienic water sources) are surely necessary, and in some places sufficient to address water needs. But as water rights are increasingly privatized, and access to traditional water sources restricted, these point-source solutions will be nowhere near sufficient to address the global problem of access to clean water. See, e.g., Shiva, *Water Wars*, 2002.
[50]Sachs, *The End of Poverty*, 2005.
[51]Prahalad, *The Fortune at the Bottom of the Pyramid*, 2005.
[52]Sclove, *Democracy and Technology*, 1995, chapter 1.

failures from the start are, if nothing else, less likely to dismantle the existing social networks that provide for people's basic needs.

In the Sri Lanka case, changes to the structure of the energy economy meant rural communities could no longer count on electrification through extensions of the national grid. As development aid shifted to market-driven electrification schemes (including the 'market' created by development assistance funds), NGOs and even some private-sector organizations played an increasing role in energy provision. Similarly, in the Nicaragua case, a pragmatic approach meant accepting the realities of a global market for products and focusing only on those that could be made more cheaply locally.

Development work of all types requires balancing an acceptance of the realities of external assistance, which necessarily entails some externally imposed goal, with striving as much as possible to accommodate and respond to local priorities and interpretations. For practitioners in developing countries, this means cultivating awareness of how one might be imposing external views on the local context and then listening for, recognizing, and utilizing local expertise as a counter weight. When development assistance is understood as providing a 'technological fix' – and insofar as technology is understood to be context-independent – a host of barriers to participation by intended beneficiaries arise 'automatically,' that is, without deliberate effort or intention. On the other hand, countering the privileging of outcomes over process demands a focus on local decision-making about technology, enabling processes in which local control takes precedence over concerns around technical functionality.

Structural conditions surrounding development work and educational institutions further reinforce an emphasis on outcomes,[53] which are amplified by engineering's focus on making the technology 'work,' on its narrow problem framing, and on the desire to 'complete' one project in order to move on to the next. But local control by itself may not be enough when there are local pressures toward specific technical outcomes. In this case, social justice efforts might focus long term on the structures in the engineering profession and engineering education, and the structures within political and economic development regimes, that push projects toward outcomes over process. As stated above, good process does not necessarily ensure a good outcome, of course, but it does ensure good planning in case of a bad outcome.

Conclusions: engineering for development revisited

The trend in engineering for development involves the proliferation of non-profits forming explicitly *as engineering organizations* doing development work. While many of these organizations acknowledge the centrality of interdisciplinary collaboration in their work, their naming as *Engineers* without Borders, *Engineers* for a Sustainable World, and *Engineering* World Health reinforces a disciplinary separateness that contributes to a silo effect. These organizations chose to organize by profession rather than by geography, by specific areas of need such as water or energy, or by

[53]In the US, for example, the Accreditation Board on Engineering and Technology (ABET) provides templates for engineering programs that are set up entirely according to educational outcomes (ABET 2008).

some other logic.[54] Engineers without Borders appear to draw its name from Doctors without Borders and is modeled after that organization in some sense as (largely independent) professionals acting across national boundaries to address people's immediate needs. But engineering work is entirely distinct from medicine, regardless of the aspired status of the profession, and the model of sweeping in, performing the crucial surgery, and moving on does a disservice to the public understanding of what robust engineering entails. Discourse around engineering as a profession commonly makes comparisons to medicine and law, but rarely if ever to feminized professions such as social work, librarianship, or nursing. Evocation of the classic (but also high-paying) masculinized professions gains prestige and recognition for the engineering profession.

Unfortunately, the effort by engineers to mimic medicine and law elides key differences between engineering and the classic professions, most notably the embedded nature of engineering *versus* the autonomy enjoyed by doctors and lawyers (classically speaking).[55] Engineering is perhaps more akin to public health than to medicine when one considers the centrality of policymaking and the need to attend to the local context, the importance of infrastructure and its complex relationship to public education, and the ways in which being embedded in both public and private organizations is simultaneously necessary and problematic for the work. Also as with public health, engineering problems are difficult to define and to bound, interdisciplinary teams must collaborate on different facets of the problem to ensure robust solutions, and final 'solutions' are rarely achieved, but each partial solution makes people's lives better.

In the most problematic engineering-for-development models, on the other hand, engineers act unilaterally as if they were autonomous, striving to achieve an ideal model of development that does not correspond to the problems faced. This unilateralism presents obstacles to effective, socially just development work, specifically by focusing on technological functionality as the principle, even exclusive measure of project success and thereby under-attending to social power relations and inhibiting cross-disciplinary collaboration. It also fails to account for larger structural and infrastructural considerations, including both broad economic forces as well as the deficiency model of development that plays into those forces. The end result is a situation in which outsiders arrive with an agenda for change, they implement that agenda, and then they depart, fully intending that the host community will continue to follow their agenda. To be sure, such agendas are typically conceived in the interests of the local community members; there need be no conspiracy here.[56] Nevertheless, after implementing their projects, almost all development organizations eventually and according to the plan, leave. This

[54]On the other hand, organizations like Practical Action (practicalaction.org) and Water for People (www.waterforpeople.org) provide models that successfully blur disciplinary boundaries and de-center engineering as the key expertise in addressing development problems.

[55]Zussman, *Mechanics of the Middle Class*, 1985.

[56]At this level of analysis, anyway. A case could be made for conspiracy at a higher level of analysis, where wealthy nations' interests direct international development policy. International economic institutions, including the World Bank and the International Monetary Fund, have been roundly criticized for practices that make development loans contingent upon the adoption of policies that liberalize finances and trade, privatize state enterprises, and deregulate industries. Steger, *Globalization*, 2003, pp 52–55.

problem is magnified to the extreme in international exchange programs, where external assistance storms in and out in a matter of a couple months, if not weeks.

These issues raise the central questions of social justice: Who benefits from a given activity? Who pays for that benefit? And at what cost? Whenever intended beneficiary communities pay a price for development interventions – however modest and in whatever form that price may appear – development project proponents need a good rationale. And whenever development workers benefit, similar reflection is required. From our cases, however, it is apparent that the costs and benefits are likely to manifest in ways difficult to see in engineering-for-development projects that are focused primarily on technology.

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