

**AC 2010-914: ENGINEERING AND SUSTAINABLE COMMUNITY
DEVELOPMENT: CRITICAL PEDAGOGY IN EDUCATION FOR
“ENGINEERING TO HELP”**

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Engineering and Sustainable Community Development (ESCD): Critical Pedagogy in Education for “Engineering to Help”

“Don’t come here [to my community] to help! Come here to listen, to find out if our [community’s] struggles are your struggles. Then and only then, we can sit and discuss how, if at all, we can work together.”

--Gustavo Esteva, community activist in Chiapas, Mexico, challenging engineering students enrolled in the course Engineering and Sustainable Community Development

Abstract

Over the past ten years, engineers and engineering students and faculty have increasingly turned their efforts toward “underserved” communities. Such efforts raise important questions. Is there anything problematic with wanting to help a community? How do engineers listen to a community? If invited, how do engineers work with a community?

Wondering about questions like these in relationship to engineering courses, design projects, volunteer activities, or international assignments motivated us to develop a project in critical pedagogy entitled *Engineering and Sustainable Community Development*. Our project is a critical pedagogy, one aimed at enhancing students’ knowledge, skills and attitudes to reflect on the historical and political location of engineering, question the authority and relevance of engineering problem-solving and design methods, and “examine their education, including learning objectives, the course syllabus, and the textbook itself” (Riley, 2008, p. 113). Specifically, our project is aimed at engineering education as it relates to a diversity of these efforts, which we call “Engineering to Help” (ETH). ETH initiatives often exist under names such as community service, humanitarian engineering, service learning, Engineers Without Borders (EWB), Engineers for a Sustainable World (ESW) and Engineering World Health (EWH). There has been a blossoming of ETH-related programs in the US and abroad, as evidenced, for example, by the large number of EWB chapters in universities worldwide and the upsurge of engineering design courses and extra-curricular activities with ETH-dimensions and goals. At the same time, there is increasing questioning into and assessment of the processes and outcomes of such projects (e.g., Schneider, Lucena and Leydens, 2009; Nieuwsma and Riley, 2010). Engineers have, up to this point, rarely engaged in such critical questioning: generally, there is a lack of student- and faculty-friendly critical reflections of engineers’ involvement in ETH work. The question arises: what critical reflections might emerge from learning about the history of engineers in development or about the complexity of engaging and listening to communities? To fill that void, we conducted historical, ethnographic and other investigations.

The main outcomes of this project are a course and a book for engineering students, faculty and practitioners involved in courses, programs and projects related to ETH. Here we outline the main elements of this project and provide recommendations on where and how to use it in engineering curricula.

1. Background of this project

Our journey to ESCD began in a previous curricular experiment in humanitarian engineering. After receiving a large grant from the Hewlett Foundation in 2005 to create a program that would change the way we traditionally teach engineering to students, engineering and liberal arts faculty involved with the grant chose to create an initiative called “Humanitarian Engineering” (HE) without being aware of what the synthesis of these two words really meant. Most engineering faculty viewed HE just as “engineering for the common good” and assumed that engineers doing good had a fairly simple history. After all, if engineers with good intentions have always been around doing good for people in the same ways, why should they care about understanding their history?

Slightly more suspicious of the term “humanitarian,” liberal arts faculty involved in this grant began a historical and philosophical exploration of the term under a NSF grant on Humanitarian Engineering Ethics (HEE). We learned about humanitarian medics and relief workers emerged in the 19th century, became organized under the International Red Cross, played significant roles in WW II, but until the 1960s included no engineers. In short, the history of humanitarianism and the histories of engineering for most of the 19th and 20th centuries are not connected. In this historical journey, we came across Doctors without Borders (MSF), perhaps the oldest and most comprehensive approach to humanitarian work by a profession. It became clear that the very recent Engineers Without Borders (EWB), and other similar organizations, found inspiration in MSF yet were doing something very different. In short, most engineers that we work with wanted the label “humanitarian” yet they were doing something else: community development.

If our engineering colleagues and students are doing community development, we owe it to them and to ourselves to understand the history of how engineers came to be involved in community development in the first place. Still under NSF funding, we made a thematic shift in our curriculum development from HE to ESCD. A multidisciplinary faculty team (engineering, anthropology, cultural studies, communication and rhetoric, STS, philosophy) began course development in the summer of 2008 and offered the first experimental course on ESCD in Spring 2009 (see section 8 below). The breath, depth and complexity of material needed to appropriately address sustainability, development, community and their relationships with engineering in just one course made us realize in Spring 2009 that we needed to write a textbook for engineering students and faculty involved in ETH courses and activities. Since that time three of us have

written the book *Engineering and Sustainable Community Development*, published by Morgan & Claypool in March 2010. We outline here the book content, which includes an account of students’ experiences in the ESCD course. Following the book’s structure, this paper begins by exploring the history of engineers’ involvement in community development, then contrasts design for industry with design for community. We also examine ways in which engineers do and should engage and listen to community members’ perspectives, an examination that includes two actual SCD case studies. Finally, we describe the course ESCD as well as the limitations and recommendations for this project.

2. Historical overview of engineers and development

To understand the present and future possibilities and constraints for engineers involved in sustainable community development (SCD), we have traced episodes of the history of engineers’ involvement in development, from 18th century colonial development to 21st century SCD, and tried to answer the following questions: How did engineers first get involved in development? How have engineers been engaged in imperial, national, international, and sustainable development? What kind of historical, ideological, and institutional factors might have contributed to engineers’ complex engagement with the groups of peoples (tribes, communities, villages, etc.) that they are supposed to serve? To what extent might this history constrain engineers’ ability to effectively define problems and implement SCD solutions? Definitions of SCD center on “the importance of striking a balance between environmental concerns and development objectives while simultaneously enhancing local social relationships. Sustainable communities meet the economic needs of their residents, enhance and protect the environment, and promote more humane local societies” (Bridger and Luloff, 1999, p. 381). Due to the limitations of time and space in this paper, we have only outlined in Table 1 our historical findings:

Table 1: A historical overview of engineers’ involvement in development and views of community¹

Historical period	Engineers’ primary emphasis	Engineers’ main view of Community
Engineers and the	To transform nature into a	Communities as sources of

¹ These are broad historical generalizations that perhaps apply more to engineers from certain countries than from others. For example, beginning in 1980s concerns about economic competitiveness with Japan were more prevalent among US engineers than among engineers from other countries. See Lucena, J. C. (2005). *Defending the Nation: US Policymaking in Science and Engineering Education from Sputnik to the War Against Terrorism*. Landham, MD, University Press of America. For a comprehensive list of supporting references for these historical periods, see Chapter 2 of our book *Engineering and Sustainable Community Development*.

development of empires (18 th and 19 th centuries)	predictable and lasting machine that could be controlled to ensure their imperial patrons a return on investment and display superiority over indigenous people (Headrick, 1988; Adas, 1989).	potential imperial subjects to be organized in ways that made it possible to tax them, convert them to the religion of the empire and often force them into labor for the construction of imperial projects.
Engineers and national development (19 th to 20 th centuries)	To map territory and natural resources of new countries; to build national infrastructures to connect dispersed populations into a national whole and integrate their productive capacity for national and international markets (Diacon, 2004; Lucena, 2007).	Communities as part of a larger national whole (national subjects) that needed to be brought into functional <i>order</i> with other parts of the nation to ensure its <i>progress</i> .
Engineers and international development (20th century)	To develop and modernize the world through science and technology; to move “traditional” societies from their current stage of backwardness and launch them through a stage of “take-off” by implementing large development projects (hydroelectric dams, steel mills, urbanization) (Adas, 2006).	Communities as obstacles to “efficient” economic production and mass consumption. Local communities to be convinced, transformed or coerced to join the modernization path by abandoning their subsistence economies, increasing their extraction of natural resources and manufacturing capacity to eventually reach a stage of high-mass consumption.
Engineers and the questioning of technology (the 1970s).	Development engineers focused on providing communities’ <i>basic needs</i> in shelter, food, and water with the goal of making them productive and incorporating them into the economy	Communities viewed in terms of what they lacked (<i>deficiencies</i>) and humans in terms of basic need parameters (e.g., minimum body temperature; maximum number of days without water or food, etc.)
Engineers and the “lost decade	Most began to embrace economic competitiveness as	Local communities disempowered as they faced

of development” (the 1980s)	Japan emerged as a technological threat (Lucena, 2005); development engineers engaged in structural adjustment, i.e. expansion of free markets, reduction of government regulations in the marketplace, and encouraging privatization of public services.	the challenges of free-markets under unequal competition and the diminishing of state functions, mainly health, education and other forms of social protection
Engineers move toward sustainable development (1980s-1990s)	Most continued to embrace economic competitiveness; few began to consider sustainable development through a systems approach but mainly in its “weak” form (IEEE, 1991).	Same as in the 1970s and 1980s
The explosion of “Engineering to Help” (ETH) activities (2000-present)	Most still embrace economic competitiveness; some committed to help the poor and disposed in problematic ways	Same as in the 1970s and 1980s but with some attempts as incorporating communities through participatory practices

We have seen how our students come to appreciate the importance of the *history of development* in shaping current institutions, practices, ideas, and assumptions about how engineers work with community. As every epoch of development has positioned engineers differently with respect to community, often in problematic ways, students come to realize that the present is no different. Clearly, current engineering practices in SCD and ETH have been shaped by this history and, in most cases, communities continue to be ignored, disempowered, or simply treated like an industrial client, in the best of cases.

3. Why design for industry does not work for design for community

Of all engineering activities, design is perhaps the one creative process where science, math, art, economics, function, form and experience come together in the conception, development and implementation of a system or artifact for a specific purpose. Design is at the heart of what engineers do. After participating in design workshops, teaching an engineering design course, and conducting ethnographic work on engineering design activities at large high-tech companies

like Airbus, Boeing and Honeywell, we have come to appreciate the challenges that engineers face when teaching, learning, and doing design. Yet after conducting numerous interviews with students and faculty involved in what we call “design for community,” we became concerned about how the assumptions, methods, concepts and practices underlying many of their design projects come from practices born in industrial and corporate settings. In our course and book, we have sketched an anatomy of senior engineering design with the following goal: To help students identify and question the underlying assumptions, concepts, methods and practices in their engineering design courses and projects so they can assess the appropriateness of these for design for community.

After a detailed dissection of the design project that won an award one of the main engineering societies in the US for “Exceptional Student Humanitarian Prize,” we analyze a design course, the site where projects like these are conceptualized, planned, developed, tested and written up, all activities for which students receive a grade. By dissecting a design project and the constitutive elements of a design course, we provide engineering students and faculty with critical reflection opportunities designed to question the assumptions, methods, processes and concepts in design-for-community projects, with the goal of helping them transform their own design practices for the benefit of communities.

4. Engineering with community

After conducting an extensive literature review and researching and developing two case studies on SCD, we developed a definition of “community,” identified the main challenges for engineers to deal with communities, and provided an outline for engineers to prepare for work in SCD. “Community” has multiple, competing definitions and meanings, depending on the context. We value definitions that are dynamic (not drawing fixed boundaries between inside vs. outside) and flexible enough to account for variable contexts (e.g., temporary vs. long-lasting communities), but that can also provide us with some guiding principles for engagement and reflection. As a result, we side with community-development practitioners who define community along the characteristics in Table 2:

Table 2: Key characteristics of community (summarized from (Mathie and Cunningham, 2008))

<p>1. Relationships among its members</p>	<p>Belonging to a community means being involved with the other members of that group in some way. This may seem obvious, but it’s important to realize that the <i>nature</i> of these relationships can be highly variable.</p>
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	Relationships might be new and weak, as in the case of a group of people of different backgrounds coming together for the first time after a disaster (e.g., a tent city created after a hurricane) or old and strong, as in the case of a people from a village with ancestral attachments to each other. In either case, development projects should aim for respecting and strengthening these relationships in ways that are appropriate to the communities.
2. Relationships with place	“Place” is loosely defined. Frequently, members of a community identify with a particular geographical place (like a village or city) where they are from or where they live. But the place can also be virtual (like an online space, or a women’s organization). We argue that development projects should aim for respecting and strengthening this relationship to place as defined by community.
3. Differences in power and privilege	These differences could vary in degree, from small—as when dictated by slight status difference—to very significant, as when shaped by a combination of socio-economic status, gender, race, and caste. In any event, development projects should aim for respecting these differences even they might seem to go against Western ideals of equality. When a particular subgroup of the community appears to be oppressed, it is not the role of the Western “expert” to relieve them of this oppression but rather to enable them to seek alternatives if the members of the subgroups desire to do so (see also Guijt and Shah, 1998/2001, Rambaldi, Chambers, McCall and Fox, 2006, p. 162-187).
4. Alliances with a common purpose or purposes	Communities may come together for a variety of reasons, whether for commerce, kinship, entertainment, or political cause. The degree of participation in these purposes may vary, depending on the needs and desires of individuals involved (Mathie and Cunningham, 2008, p. 7). Development projects should aim for awareness and understanding of these purposes.

We list here the following challenges for engineers to deal with community:

- Engineering Problem Solving (EPS), and how EPS makes it difficult to put community at the center as it forces students to draw a technical boundary around problems and become suspect of those perspectives that do not use EPS for problem solving (Downey and Lucena, 2006).
- Engineering mindsets, and how they can make it difficult to effectively consider community, especially issues of social justice (Riley, 2008)
- Curricular design and ETH projects and why most engineering for development initiatives are more about students and not about communities.

- Engineers’ beliefs about development.

In both the course and the book, we conclude our analysis of the relationship between engineering and community with a plan that prepares students for SCD work, and includes steps such as incorporating opportunities for self-reflection before and throughout the project; finding meaningful ways to learn about the community students are working with—their history, their language, their values; making plans for “failure;” and developing meaningful project assessments (see also Schneider, Leydens and Lucena, 2008).

5. Listening to Community

From exploring a number of development projects—large and small—a recurring lesson emerges: that failure to listen to and meaningfully address community perspectives played a significant role in the failure of such projects (e.g., Salmen, 1987; Burkey, 1993; Slim and Thomson, 1995; Mason, 2001; Jackson, 2005; Adas, 2006; Easterly, 2006; Salmen and Kane, 2006). Of all skills for SCD, listening is one of the most important yet one of the most undervalued in engineering education. We have mapped how *basic listening* is positioned within engineering education, developed the concept of *contextual listening*, identified barriers to and benefits of contextual listening, and proposed a listening-centered approach suited to SCD contexts (see also Leydens and Lucena, 2009).

We have identified that the few courses or programs in engineering education that include listening do it as basic listening, i.e., hearing or paying attention to the verbal and nonverbal messages of any speaker, such as a client, customer, local community member, coworker, or instructor. Basic listening is thus framed as a dyadic process of speaking (output) and hearing/receiving information (input).

Unlike basic listening, we propose *contextual listening* as a multidimensional and integrated understanding of the listening process (Leydens and Lucena, 2009). Such listening facilitates meaning making, enhances human potential, and helps foster community-supported change. The characteristics and desired outcomes of contextual listening are:

- Integrating history and culture
- Being open to cultural difference and ambiguity
- Building relationships
- Minimizing deficiencies and recognizing capacities
- Foregrounding self-determination
- Accentuating shared accountability: How the “ours” vs. “theirs” becomes OURS

After analyzing the main barriers to contextual listening in both engineering problem solving (EPS) and engineering design courses, we show how contextual listening 1) counters biases common in SCD contexts, 2) fosters a community-centric approach to problem defining and solving, and 3) integrates multiple perspectives and sectors.

6. Case study: Sika Dhari's Windmill

We researched and developed a Sustainable Community Development (SCD) project implemented in Sika Dhari village in western India. In this project, an engineering professor teamed up with a non-governmental organization (NGO), the US Environmental Protection Agency, a group of her graduate students, and others to work with the villagers of Sika Dhari in designing and implementing a windmill. The windmill is used to generate energy for powering flashlights in the village. Throughout this project, the engineering professor was committed to soliciting community perspectives and participation in all stages of the project. She and her students participated in a community meeting with the villagers, where the villagers demonstrated a significant familiarity with development projects, and communicated this knowledge and their desires to the engineering team.

In the implementation stages of the project, however, the team ran into some problems, including technical failure of the charge controller and safety testing. Both problems were mitigated thanks to the involvement of one of the villager's residents, a professionally trained electrical engineer. However, his involvement brought new difficulties to the project. Given these difficulties, the engineering professor is no longer in contact with the villagers of Sika Dhari. She believes that the windmill is indeed up and running, and that the villagers see the project as a success. For her part, the engineering professor has gone on to plan a new wind project in a neighboring country and begun to devote significant energy to urban sustainability projects in the United States, in her home city. There is a part of her, she indicated, that questions the feasibility of SCD projects abroad. She has come to question who in fact benefits more from these projects—the villagers, or the students who are sent there? During one of our research interviews for this case study, she acknowledged that, “What I found is people in the villages are smart, they know what’s happening, they know what they need. They may not have funds to do certain things that they want to do, but you know this whole thing of going and doing all this is actually benefiting our students more [than the villagers] because it’s opening their eyes. So let’s be honest and say ‘Yeah it’s a good international exposure for our students but do we contribute that much to these communities?’ I don’t know. I don’t know. I seriously don’t know....I still wonder if [we] left [the villagers] alone, if they would be just fine.”

7. Case Study: Mapping Communities in Honduras

This case study is an abbreviated history of a civil engineer who effectively incorporated communities as a central part of her work. Through many events and circumstances, including learning to see water not as a physical object to be moved across space but as a resource to be protected, she conceived and implemented strategies that empower communities to take control of their own water consumption, sanitation, and treatment. Throughout her career, this engineer became an agent of organizational change, political action and community empowerment. She mobilized organizational resources and drafted national legislation to protect water as a resource, engaged social scientists in her attempts to communicate with communities, and more recently developed community-based processes to map communities and their water use. Throughout her experiences she learned that

Just by having the challenge and learning everyday that if I don't talk to people, if I don't come to people, and if I don't convince [them] of what they need to do in order to maintain and operate their system, we are not going to succeed. They are not going to succeed and we are not going to succeed. [...] Because first of all you start understanding the connection that you can be a very good technical engineer and do your technical projects, your water projects in a very neat way, and you can implement them, that's not really a challenge at all. That's easy to do somehow, you only need to assure the resources, the economic resource. But that challenge [can be stated like this:] once those projects are implemented, what is the key issue to make sure that they will last the time you have planned they should last? So that's something that you as a technical person cannot solve if you do not take into account the people that are going to be taking care of or using those systems.

Through this case study, we show that in spite of the huge challenges posed to engineering by its history with development and assumptions about design for industry, engineers—in collaboration with many other groups, such as community members, NGOs, government officials, etc.—can successfully engage communities to take greater control of their own destiny.

8. ESCD course

Our interactions with engineering students have revealed a range of perspectives on development, helping, community, and the need to listen. Those interactions catalyzed several questions: What kind of curricular journey can help students to change their beliefs and attitudes towards development? How could engineering students learn to position and assess their own knowledge and question their desires to help, while finding value in building relationships and learning from local knowledges? With these questions in mind we set out to develop and implement a course entitled *Engineering and Sustainable Community Development*. After one

year of research and preparation, a team of faculty from the liberal arts, engineering, and environmental science delivered this course with the following learning objectives. By the end of the course, we expected students to be able to

- Identify events, institutions, and actors in the history and politics of development as related to SCD and engineering
- Identify, relate, and describe the role that engineering might play in the different aspects of sustainability: economic, environmental, ethical, and socio-cultural
- Evaluate the strength and limitations of Engineering Problem Solving (EPS) and at least one engineering design methodology with respect to working with communities
- Analyze and evaluate project-based case studies in SCD and select criteria for such evaluations.
- Provide and critically assess definitions of SCD and their relationships with engineering

Before and after the course, we assessed students' relationship to development, observed their questioning of their desires to help people in need in far away places and of engineering problem solving as an approach for SCD, and documented their growth in learning and predispositions to work in SCD.

9. Limitations of this project

The focus of this project has been mainly on the relationship between engineers (E) and sustainable community development (SCD). The importance that we have given to community and engineers in all stages could give engineers the impression that these two are the main actors that matter in SCD. They might have created a mental model of SCD that looks like this:

Engineers ↔ Community

Although community should always be central, engineers and community are not the only actors in SCD. The relationship between them is only one among many in the larger context of SCD. So what other actors and relationships might be important for engineers to know, understand and value in SCD? We invite engineering students to consider a more complex model of SCD that might look like Figure 1:

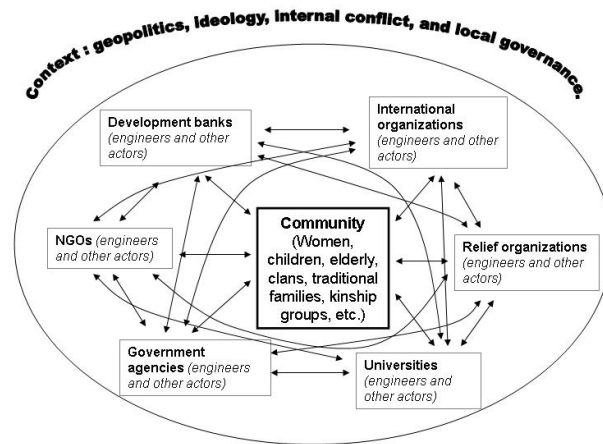


Figure 1: Network of interrelationships among principal stakeholders in SCD contexts. Note engineers' location in every kind of institution involved in SCD and expected collaborations (and conflicts) with multiple non-engineers actors.

We recognize that our project—the ESCD course and book—does not include a thorough analysis of this network of interrelationships. Other fields such as development studies, critical race studies, humanitarian studies, anthropology, cultural studies, and so on, are better suited to this challenging task. Furthermore, this book is written primarily for engineering students and faculty; practicing engineers may find this book useful, but they are not our primary audience, and they may have a different set of concerns that may not be represented in this book. It is not a field manual.

Because our focus is on engineers and engineering, we also tend to privilege explanations that place engineering at its focus. For example, we offer an extensive critique of engineering problem-solving, but do not spend extensive time exploring students' commitments to other types of identities, such as those created by race, nation, or religion. Future work in ESCD could incorporate studies of these other identity commitments.

Our research also experiences limitations since it is not firmly grounded in our own ETH field experiences but is instead based on reflections on ETH experiences by faculty and students. We hope that the two case studies have provided portraits of ETH in action, and we hope to see first-person ethnographic accounts of ETH experiences in the future.

Finally, we recognize that our project is just one step in studying the world of ETH activities, as these are found in many forms, schools, countries, projects and organizations. We are encouraged to see others taking on the task of researching, conceptualizing and transforming ETH-related activities through their own work (e.g., Caroline Baillie at the University of

Western Australia, Nalini Chhetri at ASU, Dean Nieuwma at Rensselaer, and Donna Riley at Smith College).

10. Recommendations from this project

After completing the book and having offered the ESCD course three times, we propose a number of recommendations for those engineers who want to commit to SCD work for the long-term. We invite them to

- Complement their engineering education and develop a life-long learning attitude by taking courses related to SCD (e.g., development studies, cultural anthropology and international political economy) that will help them further understand, appreciate and deal with the context, institutions, and actors that make the world of SCD.
- If committed to a career in SCD, embark in a graduate program related to SCD such as the Engineering for Developing Communities Program at University of Colorado-Boulder, Peace Corps Master's International Program in Civil and Environmental Engineering at Michigan Tech, the Masters Program in Humanitarian Assistance at Tufts University's Feinstein International Center, or the Master's in Development Practice at Columbia University's Earth Institute.
- Intern or co-op, even as an unpaid volunteer, with SCD-related institutions such as Water for People (WFP), International Development Enterprises (IDE), or Mercy Corps. Make sure that the organization you are volunteering with has an institutionalized program to recruit, train and mentor volunteers so as not to become a burden to the organization.
- Develop and enhance your ability to listen beyond basic listening.

For faculty involved in SCD-related program, courses or initiatives, we recommend to

- Use our book early in design engineering education, preferably in introductory design courses, so students have time to assimilate the questions and issues that we raise about senior design.
- Consider using specific chapters for specific purposes. For example, Chapter 2 on the history of engineers and development can be used in Intro to Engineering courses, Chapters 4 and 5 on community and listening can be read prior to any service learning activity (and certainly prior to any design-for-community project), Chapters 6 and 7 on the case studies can be used during any junior-senior class dealing with water, civil infrastructure or renewable energy, and Chapter 3 on why design for industry does not work for design for community should be certainly considered prior to any senior design project involving communities.

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