AC 2007-2072: RESISTING NEOLIBERALISM IN GLOBAL DEVELOPMENT ENGINEERING

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Resisting neoliberalism in global development engineering

Abstract
In recent years we have seen an explosion of interest in global development engineering on our campuses. Driven by a range of goals including addressing basic human needs, working to end poverty, or providing students with cross-cultural design experience in preparation for careers in a globalized economy, numerous small-scale engineering projects have proliferated in developing countries, either driven by or with participation from U.S. engineers and engineering students. Many different models have been employed to this end, curricular and co-curricular, in collaboration with foreign governments, educational institutions or non-governmental organizations, with entrepreneurial, sustainable, appropriate technology and/or community-based approaches to design.

These engineering projects are occurring in the context of globalization and broader economic development efforts. It is important that we in the engineering community are aware of and participate in discussions around the underlying assumptions and values that accompany these trends, to learn how our efforts are (perhaps unwittingly) influenced by and even a part of them. In particular, at the heart of many development efforts lie economic and policy perspectives that are critiqued internationally and domestically as *neoliberalism*; as engineers learn about neo-liberalism we can clarify our stances in relation to it as we undertake global development work.

As part of this conversation, I take the position that engineers ought to resist neoliberalism in global development engineering. Although the definition itself is contested, here I define neoliberal approaches to development as those that place ultimate faith in free markets and rely on what amount to "trickle down" theories to predict redistribution of wealth. Coupled with and following from this economic approach are policy perspectives that include opposition to collective bargaining, removal of regulations on industry and trade, minimization of governmental support for social services, and privatization of public goods such as clean water. Responsibility shifts from communities or public governance to individuals.

How can engineers and engineering students undertaking engineering projects for global development resist neoliberalism? Are there effective models of technological development that depart from -- or transform – neoliberal frameworks? What can we learn from the community-based learning literature that may be adapted for work in developing communities? Through a series of case studies, we explore models for engineering development projects and student participation in them. Potential pitfalls are examined, and the implications for global development efforts within engineering education are discussed.

Introduction

There has been an explosion of interest in global development engineering within engineering education in recent years. ABET's criterion 3 requires that students obtain "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context."[1] The interpretation of this phrase varies widely within engineering. Here I argue that such an education necessarily requires an awareness and critique of the phenomenon of globalization and specifically of neoliberal policies and practices worldwide.

For some in the engineering community, understanding global context is driven by transnational corporations' needs, specifically addressing capacities of U.S.-trained engineers for conducting business internationally. Many view technology's role in globalization optimistically, without a critique of globalization but rather an acceptance of it, or a desire to further its ends through technological development. Others in the engineering community approach globalization with an idealistic intention to address or end poverty, typically through small-scale development projects. Regardless of the approach, a critical understanding of globalization as cultural, social, political, and economic phenomenon is necessary to avoid distortions in understanding that can have grave consequences.

In particular, it is paramount that we consider where our work as engineers fits in a framework of globalization that is predominately neoliberal. Neoliberalism is an economic approach to development championed by Thatcher and Reagan in the 1980s, which places ultimate faith in free markets and relies on what amount to "trickle down" economics to address poverty and debt. Coupled with and following from this economic approach are policy perspectives that include opposition to collective bargaining, removal of regulations on industry and trade, minimization of governmental support for social services, and privatization of public goods such as clean water. Responsibility shifts from communities or public governance to individuals. The International Monetary Fund has placed many neoliberal policy conditions on debt-ridden countries, constraining their ability to implement much-needed social and economic programs. (See Harvey[2] for a more detailed look at neoliberalism).

Many large-scale engineering projects have been launched in developing countries with the assistance of the World Bank and the International Monetary Fund. These projects have left a long legacy of case studies that can be analyzed to determine what works and what doesn't. However, accounts of the same project can vary widely, so it is important to read multiple accounts with a critical eye. Involvement in small projects that are independently funded have their own histories of failure, and it is important to consider how one's involvement in such an independent project relates to overall neoliberal trends, and to the economic policies and direction of local and national governments.

How and why so many projects fail is well documented in numerous case studies. It is easy to repeat past mistakes without understanding previous failures. Hammer[3] identifies the following pitfalls in aid projects carried out by aid agencies, which also apply to NGOs and others:

1) Projects should be formulated in and by the communities that will ultimately benefit.
2) On-site feasibility studies must be undertaken before a project begins to ensure that it has a chance of success.

3) Autonomy and economic independence, and the ability to maintain or repair technology are key factors in the long-term sustainability of any project.
4) Projects require thorough market analyses that include an assessment of actual production costs, and time people have available to do the required work.
5) The appropriateness of a technology should be assessed for the specific community in which it may be implemented. This requires being in the field with the recipient community for some time.
6) Flexibility is required so that the project can evolve over time.
7) Responsibility does not end when the funding ends. The limitations on people's availability must be made known up front before a project begins.
8) Communication and networking are essential.
9) Insurance should be provided so that if a project fails the community does not end up bearing debt.
10) Know who each partner is in a project, and what they are interested in gaining from the project. Groups that are established and cohesive are more likely to stay together.

Assessment throughout a project, and particularly years out, is often poorly executed or nonexistent. Critical thinking about adverse impacts or the social context and cultural impacts of projects is often lacking. A disconnection from or lack of awareness of colonial histories can mean that such power-laden relationships are quickly and easily replicated. NGO models are additionally susceptible to charity approaches that re-inscribe power dynamics, conceptions of one-way technology transfer, vicissitudes in funding and therefore disappearing from the scene despite best intentions, and working on too small a scale to have a lasting impact.

Underlying most engineering projects at any scale is an unquestioning acceptance of capitalism and free markets. This often leads to an unspoken or even unwitting acceptance of neoliberal approaches that advantage the United States and other developed countries. Without a conscious resistance of neoliberalism that asks questions about who benefits and who loses, it is very easy to end up with a situation that does not profit the intended beneficiaries at all.

Below I discuss various approaches for global education within engineering, and provide some thoughts on how these endeavors might fit in our current context of globalization. I close with some ideas for resisting neoliberalism in engineering education.

Existing Models for Global Development Engineering Education

Study Abroad and Exchange Programs
Several institutions seek to prepare students to become global citizens through exchange programs, which look similar to traditional exchange or study abroad programs at liberal arts colleges and universities, typically with some additional project, co-op or internship program to integrate engineering practice into the experience. Gerhardt[4] describes the Global Engineering Education Exchange Program, an international student exchange program that includes internships. Owusu-Ofori et al.[5] describe a global engineering education project at UST in Ghana that involves a student exchange program in which students spend a semester at the partner institution, transferring credits to the home institution, and cooperate on a design project in multicultural teams. The design project is intended to initiate technology transfer related to the

use of aluminum in automobiles in Ghana. Lloyd and Rosenberg[6] discuss education-industry partnerships in mechanical engineering. Foreign language learning is initiated in middle and high schools (French, Spanish or German, and sometimes Chinese or Japanese). Then in the first two years of college, further language and cultural awareness preparation leads to a junior year study abroad and co-op program. In their senior years the students remain involved in the program as mentors to their junior peers. Hirleman et al.[7] discuss the Global Engineering Alliance for Research and Education (GEARE) at Purdue, Karlsruhe and Shanghai Jiao Tong Universities, an 18-month exchange program that includes language and cultural study , study abroad, two three-month internships – one domestic and one abroad, and two semester-long design experiences in multinational teams, one domestic and one abroad.

Additional models seek to leverage developments in communication technology, using distance learning approaches to form transnational exchanges or design projects. Doerry et al.[8] describe a distance learning approach to global engineering education, creating a virtual "global engineering college" for learning across cultures and national boundaries. The stated rationale for such an endeavor is the economic trend toward globalization and corporate needs for engineers with the abilities to communicate across cultures, work in multicultural teams, and work across distributed geography. Rojas-Oviedo[9] describes a virtual center established in Mexico to promote bi-national economic development, promoting traditional exchange programs as well as a model of trade focused between neighboring countries for mutual benefit.

Study Abroad programs emulate the successful model employed at many liberal arts institutions with an engineering twist that adds design or internship/coop experience. The inclusion of language and cultural study is important, but the constraints of engineering curricula often limit the extent of language and cultural study that can be achieved. Many of these programs do not emphasize an understanding of globalization as an economic, political, or cultural phenomenon. Rather most seem concerned primarily with preparing students for careers in transnational business, which requires some knowledge of other cultures and languages. There are competing interests between critiques of globalization as a phenomenon and neoliberal policies and practices in particular and multinational corporations that sponsor or participate and many of these programs. This raises a point that sociologist of the professions Robert Zussman made in his 1985 book, *Mechanics of the Middle Class*, that because engineers are embedded in industry, or in the military, they typically serve the ends of profit-making, or defense, and it has not traditionally been considered a professional duty to question those ends.[10]

Programs for Global Studies in Engineering

Some institutions have developed concentrations or degrees with a global perspective on engineering. The University of Colorado at Boulder has a program in Engineering for Developing Communities with a mission "to educate globally responsible students who can offer sustainable and appropriate technology solutions to the endemic problems faced by developing communities worldwide (including the US)."[11] The program has learning, research, and service components. Mazumder and Bean[12] describe a global concentration in engineering at Michigan which requires international experience, course content including a required cross-cultural course. Focus countries are China, the UK, and Mexico. Baylor University offers appropriate technology as a focus area in their Master of Engineering program, with emphases on cultural anthropology and entrepreneurship, particularly related to product development. Baylor's work is directly

linked to religious missionary and humanitarian development organizations.[13] Mihelcic et al.[14] describe a masters of science in civil and environmental engineering at Michigan Tech that incorporates service in the U.S. Peace Corps. At an even grander scale, Quevedo-Camacho et al.[15] discuss criteria for educating the Ibero-American engineer, who would have not only the usual attributes of an ABET-accredited engineer, but also specific knowledge about cultural, economic, social, and political factors in design within Ibero-American nations.

These programs seem to situate themselves somewhat differently in relation to globalization, seeking to educate engineers who can work with a variety of international aid groups, governmental and non-governmental. It is crucial that such programs engage in critical analysis of the organizations with which they work. U.S. Peace Corps projects often fail, and it is important that students involved with that work have critical analysis tools to understand their experiences and learn from case studies. Similarly, missionary work has a controversial history, particularly in relation to indigenous culture, and students must engage with the ethical implications of working as a professional engineer with a missionary organization.

Courses in Sustainable and/or Appropriate Technology Education

Recent years have witnessed a renewed interest in Appropriate Technology within engineering education, with a strong emphasis on ecological as well as economic sustainability. For example Parsons[16] was engaged in developing a handbook for U.S. engineering students planning to work in developing countries. Emphasis was placed on listening to the community. For a review of appropriate technology courses that involve a service learning component see Sandekian et al.[17] A strong model for service learning and appropriate technology is the ETHOS program at the University of Dayton. The program connects students with service learning opportunities in developing countries, and offers a course which includes language and cultural preparation as well as readings in appropriate technology to prepare students.[18] Explicit recognition is made of the need to be interdisciplinary and focus not solely on technical issues but also social, political and economic issues in preparing students for a summer service learning experiences that lasts from six to sixteen weeks. Riley and Miller[19] and Riley and Bloomgarden[20] discuss strategies for incorporating economic, social and political aspects of globalization in an engineering course on global development that has a service learning component.

There are two main problems with the resurgence of interest in appropriate technology, and with service learning as a vehicle in courses on engineering and global development. The first is the inevitable competition between the educational needs of the engineering students and the community's needs. Amadei's use of the phrase "viewing the developing world as the classroom of the 21st century"[11] is illustrative of the tension here – even with the best intentions, it becomes problematic to attempt to meet both sets of needs.

The second problem with appropriate technology applied today is the very context of globalization in which it is now occurring. Without the kinds of governmental social structures that existed in the 1970s and 1980s, it becomes essential that projects are able to survive in the current market economies without any governmental protections or incentives. Assessment becomes even more important, and a greater percentage of projects will fail. It is telling that appropriate technology has been reinvented with a neoliberal twist in which appropriate technology is geared toward the "creation of a middle class."[21] The logical progression of such

an approach is that a project designed to bring labor to a particular locale will eventually export that labor to cheaper and cheaper markets. The project may succeed globally, but fail to alleviate poverty locally, and fail to meet a standard of "appropriate technology."

Co-curricular models

There has been a proliferation in recent years of non-profit organizations that seek to match engineering students with projects in developing countries – these include Engineers for World Health, Engineers for a Sustainable World, and Engineers without Borders. They hold up similar values – meeting basic human needs through engineering, working closely with communities in a partnership in which communities retain autonomy to define and control the project. They work from similar models, where students raise money for and become involved in the technical work for a developing community (sometimes in the United States, but often in a developing country), and spend a small amount of time in that country doing some of the work.. A team of professional engineers and a faculty advisor work with the students, but there is usually no formal classroom component required. Many engineering education-based projects do not involve social scientists or economists or others with significant cultural knowledge. Attempts are made to involve the community, but without experts in community involvement, this can prove to be quite difficult. While efforts are often made to include social scientists in this work, the structure of the organizations (particularly the titles themselves which suggest an exclusivity, no matter how vehemently students may insist that all are welcome) and operating models make such collaboration more difficult.

As with the service learning in formal courses, it can happen with these organizations that U.S. engineering students' needs come before the community's needs. It can happen that students raise thousands of dollars that are used to transport them halfway around the world in order to perform what amounts to basic construction labor. One must ask if it is more efficient, and makes a bigger impact on alleviating poverty simply to send the money and hire local labor to accomplish the same work. Why should the students' cultural experience be considered more important? Or, in order to make the work more meaningful for the engineering students, a group might easily be tempted to devise a more interesting engineering design question for students to work on, when a simpler approach would meet the community's needs.

This NGO co-curricular approach by itself provides minimal introduction to language and culture, and minimal involvement of experts in the social sciences to ensure preservation of culture and the autonomy of the community in the process. Students receive little exposure to the culture in the short time they typically engage with projects. While the principles held out for the work are collaborative and appear aimed at leveling power dynamics and learning from past failed projects, the application of the organization's values and principles is largely localized. The devil is in the details, as they say. Can the community truly retain autonomy in a given project? Will high-quality assessment be conducted prior to and following up years after the project is completed?

Internationally, it seems it is more common for individual students to placed on 12-week internships in developing countries, often working with local engineers.[22] Perhaps such placements are more feasible in countries such as Canada and Britain because students have greater proficiency with foreign languages. Working with local engineers in particular helps to

counter the false assumption many engineering students have that impoverished countries simply lack some privileged knowledge available to the U.S. engineering student that, once nobly conferred, can improve their lives.

It is especially important to understand the proliferation of these NGOs in the context of globalization and neoliberal policies. It is not coincidental that these groups are proliferating now, under neoliberalism. The type of work the groups take up, and the kinds of support or lack thereof provided by government entities affects the projects and their likelihood of success.

Critical thinking about NGOs' work, and in particular demanding thorough pre-, mid-, and post-assessments that include evaluations of economists and anthropologists as well as engineers is essential. Even NGOs with a great deal of experience working internationally can make mistakes that are culturally devastating to local communities. For example, Rotary International has come under fire from indigenous rights groups for their involvement in the Children of the Golden Triangle Orphanage Project. This project places children of the Akha hill tribe in Northern Thailand into orphanages. However, their parents are not dead – rather they have departed to Bangkok to seek available employment. The children are left in the community to be raised in extended families, congruent with Akha culture. However, the Children of the Golden Triangle Project assumes that since the parents are often seeking employment in Bangkok's sex and drug industries, the children are as good as orphaned. The orphanage separates them not only from their extended family and tribe, but also from their language and culture.[23] It would be quite easy for one of the engineering NGOs to work with Rotary on such a project, or to work with a group like the Children of the Golden Triangle Project without fully understanding the implications.

It is important to remember, and to remind our students, that there are roles for NGOs and roles for government-sponsored work; many engineering projects are and rightly should be government-sponsored. Of course, state-sponsored projects have their own liabilities and factors for failure (for example large dams create concerns over environment and displacement of communities)[24]. Still many government-sponsored projects that build infrastructure can be in many ways preferable to privatized projects where profits are exported, or to NGO projects that have intermittent and unreliable funding and are limited in scale. The IMF and World Bank can be responsible for funding some of these government-sponsored projects, which brings its own issues, potentially creating additional debt burdens or policy constraints.[25,26] Hussein[27] wrote about Egypt's plan to develop an engineering education program to educate more Egyptian engineers – this enables in-house expertise and home-grown technology to strengthen Egypt's economy.

Why should engineers resist neoliberalism?

There are volumes written about neoliberalism that point out its many flaws and consequences (see, e.g, Chomsky[28], Stiglitz[29]). Briefly, here are some reasons engineers should join in the global movement to resist neoliberalism:

1. *Neoliberalism is bad economic policy*. Proponents of neoliberalism claim that a market left to its own devices will produce efficient solutions. This view denies classic economic theory that notes the need for governments to intervene to correct market inefficiencies.[30] Many categories of market inefficiency relate very directly to engineering, particularly

those related to public goods, environmental externalities, and imperfect availability of information. Moreover, efficient allocation of goods ought not to be the only public policy consideration. Stokey and Zeckhauser[30] note that the classic justification of government intervention includes not only correction of market inefficiencies but also defense of human rights and promotion of social equality. Finally, neoliberalism has failed to deliver on its promise of wealth generation. Finally, neoliberal economic policies have failed around the world, in that they have not brought increased wealth generation that was promised, only a redistribution of wealth that has left the rich richer and the poor poorer. Economic growth has been slower under neoliberalism than before its institution in the Reagan and Thatcher era.[2]

2. *Neoliberalism promotes neither freedom nor democracy*. Proponents of neoliberalism often claim that liberalization of markets leads to stable democracies and free societies. Unfortunately this too seems an empty promise. Harvey notes that neoliberalism provides increased choices to individuals as consumers but limits their ability to fight for human rights, fair wages, or social equality. This decrease in civic involvement combined with increases in economic inequality in turn undermine democracy and the stability of governments; if the state's only function is to protect property and national security, citizens have decreased motivation to remain loyal to the nation state.[2]

3. *Neoliberalism is unjust*. Neoliberals often argue that everyone benefits from globalization and from free-market extremism. However, as Steger notes, "Integrating and deregulating markets around the world creates and sustains asymmetrical power relations."[31] Neoliberal policies serve the interests of the North and secure economic and political power for rich countries, while the South grows deeper in a cycle of debt. As the government steps out of its role protecting human rights, there are increased violations of these rights.[2]

4. *Neoliberalism does not address poverty or raise the global standard of living; on the contrary it increases wealth disparities*. Because neoliberalism does not raise living standards, but instead, as Steger notes, "the opportunities and rewards of globalization are spread unequally, concentrating power and wealth amongst a select group of people, regions, and corporations at the expense of the multitude," it becomes clear that neoliberalism will not end, or even mitigate, poverty. This is true within nations, where neoliberal economic development often leads to lower wages and part-time labor, and between nations, where one country becomes indebted to another at higher and higher interest rates. [31]

5. *Neoliberism degrades the environment*. Both Steger[31] and Harvey[2] note that neoliberal policies lead to increased ecological devastation, because the role of government in correcting environmental externalities is reduced. Furthermore, neoliberal ideology is fundamentally about limitless and unchecked consumption, which is bound to have negative environmental repercussions. Whether the issue is climate change, toxic releases, or biodiversity, neoliberal policies produce no stopping rules on environmental degradation and exploitation of natural resources.

6. *Neoliberalism does not hold paramount, and in fact runs counter to, the health, safety and welfare of the public*. By assuming the market will take care of such things as the health, safety, and welfare of the public, neoliberal approaches shirk the engineers' primary duty to society. Public health, safety, and welfare cannot be privatized; market forces do not and cannot serve these interests in any comprehensive way. Neoliberalism is at odds with fundamental values in the engineering profession.

7. *Neoliberalism increases technological divides*. Neoliberalism creates a situation in which there are technological haves and have-nots. The poor have less access to the benefits of technological innovation as a result of a singular focus on profit-making. The digital divide that separates North from South is not closing, but widening in large part due to the fact that the rich have increased access to innovations while the poor are left behind with inferior technologies. [31]

8. *Neoliberalism creates suboptimal engineering solutions*. Reducing or eliminating the role of government in providing infrastructure can lead to suboptimal system designs. In many developing countries infrastructure has yet to be built that can serve as an essential backbone for other technologies. Energy and power, transportation networks, and water and sewer systems are key infrastructural elements that are currently being built on small scales with enormous inefficiencies created by idiosyncratic local solutions that will ultimately not be able to be integrated into regional or national networks. These small scale projects occur in large part because governments are not sponsoring larger initiatives to meet these needs. Many governments are not able to provide them because of their debt burden and because of specific restrictions on IMF loans. As noted above, government sponsored projects and large-scale projects overall have their own sets of problems, but the governmental leadership vacuum under neoliberalism will not lead to long-term solutions on a national scale, leaving a patchwork of incompatible engineering solutions, with gaping holes in communities with fewer NGO connections.

9. *Neoliberalism hurts women disproportionately*. Christa Wichterich[32] details how women's roles are being redefined in and out of the labor market due to neoliberal economic policies worldwide. She argues that exploitation of women's labor, in low-wage, part-time jobs that are easily transported to other locales with even lower wages, creates numerous social problems specific to women, including infringements of women's rights and gender-based violence.

10. *Resistance is not futile, rather it is essential.* Simple awareness of neoliberalism is not enough. Particularly in the North, it is easy culturally, politically, and ideologically to rest in privilege, to be aware, maybe to feel guilty, but not to act. Proponents of neoliberalism would have us believe that "resistance is futile," that neoliberalism and globalization are inevitable. Steger notes that this masks the political choices that are being made about technology and about the economy (not to mention American foreign policy). He further notes that resistance is portrayed by neoliberals as "unnatural, irrational, and dangerous." [31] Because inaction and a lack of resistance is part of the ideology of neoliberalism, it is all the more necessary to take action. In fact it may even be necessary to resist neoliberalism in order to achieve a true awareness of it.

Some may ask if it is possible to resist neoliberalism if one is participating every day in market economies. First, it is important to distinguish between neoliberalism and market economies that include a governmental hand that intervenes in cases of market failure and to ensure human rights. Second, there are many ways to resist unjust forces – non-participation is one form of resistance, but not the only form. Gandhi famously resisted the railroad, which he felt had detrimental effects on India's poor, and yet he rode the railroads, seeking to use them to spread resistance.[33]

How can we Resist Neoliberalism?

Some initial ideas for increasing awareness of and resistance to neoliberalism within the engineering community are included below. This is meant to open up conversation on this topic and is offered as a place to start.

1. *Teach about neoliberalism*. Naturally, our community must first understand about neoliberalism. An engineering program interested in preparing its students for global interactions must teach about international economics – and central to this is the phenomenon of globalization in particular, and neoliberalism as an essential feature of its manifestation today. Similarly, an engineering course focused on global development should rightly begin with consideration of economic issues because without that understanding it is difficult if not impossible to make sound engineering decisions.[19] At Smith in our course on engineering and global development, students read and discuss several current books on development economics as well as globalization as a phenomenon (e.g., Easterly[25] and Steger[31]). When learning about development in particular, studying past projects, the models on which they were implemented, and factors in their success or failure is instructive. Riley and Miller[20] discuss the structure and content of the Smith course in greater detail. Using pedagogies that focus on praxis, connecting learning with action, will ground student critiques of neoliberalism in the real world, informing and transforming their perspectives and ultimately resulting in reflective action for change.[34]

2. *Ask who wins and who loses*. Students need to develop an understanding of power relationships, a sense of the history of colonialism and its relationship to globalization today. Neoliberal economic policies produce winners and losers, and students need to develop a sense of how market economies play out to help certain people in a society, while others may be worse off. At Smith this semester an Indian street theater group, Janya Natya Manch, is coming to perform and meet with students in the course on engineering and global development. Their play *Nahi Qubool (Unacceptable)* is a satirical examination of U.S.-India relations around development, in which technology plays a significant role. The play raises issues around power through which students can examine their own privileges.

3. *Use case studies to develop a critical perspective.* Developing a critical view of projects is fundamental to preparing engineers to work on development issues. Examining the effects of International Monetary Fund and World Bank policies and projects as case studies is essential, as is analyzing cases of NGO-sponsored projects (see Riley and Miller[20] and Riley and Bloomgarden[19] for examples of these). Analyzing case studies reveals patterns that have some predictive value for social, cultural, political, and engineering analysis. Projects can be spun as

successes or failures by different authors, so a variety of readings from a variety of perspectives is important. Classroom debates on topics such as water privatization can be effective for drawing out different viewpoints and helping students to articulate arguments on all sides of an issue. A critical view is essential for resisting neoliberalism, whether the resistance takes the form of speaking out, refusing to participate in certain projects, or visioning and building something new.

4. Conduct assessment and report it honestly. When time and again projects fail, we need to begin to ask if our models are broken. At this point, we aren't assessing enough of our projects to determine how many have failed, but my discussions with many engaged with this type of work anecdotally suggests we need to take a hard look at what we are doing. We need to be honest in assessing and reporting our projects. Swan et al.[35] and Kent[36] offer two examples of reflections from project participants. These are honest in nature and would be helpful for students to read in preparation for a project. Similarly, Riley and Bloomgarden[19] reflect on a Smith course and its effectiveness. However, students need more critical tools for thinking about the implications of their work. It is even more important to engage in and report assessment of projects, including pre-assessment. The *International Journal of Service Learning in Engineering* is a place where students can publish results and reflections from such projects. Keeping abreast of this literature, and the rest of the literature on past project failures can help us not repeat the same mistakes. In the 2007 iteration of the Engineering and Global Development course at Smith, students are engaged in pre-assessment around a collaborative project with a university in Nicaragua, which is in its early stages.

5. *The value of working with social scientists cannot be underestimated*. Lucena[37] notes that projects such as these create needs for non-engineers to participate in engineering projects. For their part, engineers must have a modicum of knowledge related to the social, cultural, political, and economic contexts of globalization, so that terms such as neoliberalism are not met with blank stares, and so that due respect is given and a true collaboration can result. Interdisciplinary collaboration is underway at Smith and three other institutions, two of which are in Nicaragua, for an initiative focused on product development education for economic empowerment in Nicaragua. The initiative will involve students and faculty from economics, business, engineering, Latin American studies, Spanish, and other disciplines. We seek to demonstrate a new paradigm for development work that is rooted in education rather than in specific projects, which we tend to have low probabilities of success. By focusing on education, we can instill capacities to generate and assess multiple projects, increasing the chances of success and economic empowerment in the long run.

6. *Enhance engineering ethics*. Barakat and Carroll[38] explore the issue of international engineering ethics education and point out some areas that lack emphasis in U.S. engineering codes but are important internationally: respect for human rights, intellectual property issues, and natural resources, as well as anticipation of the social, cultural, political, and economic impacts of technology. The authors also note the importance of U.S. engineering education incorporating into ethics education cultural differences in approaches to ethics. Rather than basing engineering ethics solely in western theories, they argue that it is important to acknowledge other bases for the resolution of ethical problems. At Smith our course on engineering and global development engages these questions and asks why certain projects are pursued, and who decides which

projects will be undertaken. Students are challenged to consider what they are willing to participate in and why, and what duties they may have to speak out and resist certain modes of action.

7. *Go public.* Assessing and critiquing what's wrong is important to do internally, and can be one form of resistance, but making such conversations public allows engineers to contribute to the greater conversation around globalization forces. Being clear about what is wrong in a public way on a specific project, or in general approaches to development, is an important leadership role engineers can take in resisting neoliberalism. Such action can also help non-engineers work through their channels to demand better engineering on future projects, or to change the course of a specific project.

8. *Be active in generating collective professional voices.* Many professional societies have been holding forums on critical issues such as water privatization. Taking clear stands and making them count by publicizing them and advocating with a higher profile is an important act of resistance. Being involved in policymaking around neoliberalism is essential – to do nothing is to lend tacit support to the status quo. Engineers must act as a profession to lay bare the contradictions between the profession's values and those encoded in neoliberal policies worldwide.

9. *Create resistant designs*. Is it possible to create technologies that inherently resist neoliberalism, or that are more compatible with social and economic contexts that resist neoliberalism? Can we insist as a profession on work contexts that resist neoliberalism? There is no doubt that engineering would change radically if we did. Examples from the history of science and technology such as Diesel's engine[39] may give us a glimpse of what is possible, as well as some cautionary tales. The engine was designed to resist large-scale industrialization by enabling small businesses to own and operate engines that operated on any fuel type. However, Diesel's goals were not realized because his invention was quickly taken up by large industrialists, although we are now seeing a return to some of the kinds of uses Diesel may have intended with the introduction of biodiesel. Nieusma[40] and Baillie and Catalano[41] provide some further visions for design that may resist neoliberalism and offer alternative frames around social justice and human rights.

10. *Be active as citizens in addressing non-engineering aspects of this problem*. Some issues related to neoliberalism seem less related to the profession of engineering. For example, debt forgiveness is a key step in addressing poverty and allowing countries to end a vicious cycle that stands in the way of economic development. Reframing globalization in a human rights framework[42] can help all of us move toward more sensible policies that protect the environment, human rights, and the health, safety, and welfare of the public. As citizens, we need to be more engaged in advocating for changes in neoliberal policies as a whole, which will in turn address the aspects of such policies that relate to engineering and technology.

Conclusions

I have argued that engineers can and should resist neoliberalism in global development. The neoliberal ideology has led to policies and outcomes including increased economic inequality,

environmental devastation, violations of human rights, oppression of women, widening technological divides, and suboptimal engineering solutions. Active resistance is needed from the profession in order to address these injustices. Engineering educators must incorporate awareness of neoliberalism and globalization in engineering curricula, doing so in such a way that results in student action. We can join the effort to reframe engineering design in alternative ways that answers neoliberal frameworks with concerns about social justice, anticipates social and economic implications of technology, and creatively imagines technologies that serve different people and different values. Engineering professionals should organize through professional societies to take specific stands to correct harmful neoliberal policies related to technology and development. Engineers should also act as citizens to change the underlying ideologies that guide policymaking, working toward a shift from an exclusively market-based frame to one that values human rights, ecology, and the health, safety, and welfare of the public.

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