ENGINEERING IN CONTEXT: ENGINEERING IN DEVELOPING COUNTRIES

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ABSTRACT: This paper is the beginning of a handbook geared toward engineering students who want to work in developing countries in a socially responsible manner. The paper discusses socially responsible engineering in the field of development assistance. It suggests that actual contributions to the development process of a country happen when the engineer truly listens to the desires of those he/she is attempting to serve. Included in the paper are examples of development projects that have been successful and ones that have failed to reach their intended goals. The reasons for these successes and failures are examined. As well, examples of engineers combining social responsibility and their engineering skills in developing countries are given. Issues such as policy, appropriate technology, working conditions in developing countries, culture, participation, women engineers, education, and ethics are also explored. This paper is intended to stimulate a discussion about the role of engineers from industrialized countries in the Third World.

INTRODUCTION

"A genuine program on the part of the wealthy nations to make prosperity a reality for the poor nations will in the final analysis enlarge the prosperity of all." (Martin Luther King, Jr.)

I'll start with a story. Nemecio Porras is a community organizer who has worked for many years in developing countries. His job is to empower poor people to solve their own problems by using money from international funding sources. In the 1970s he was sent to Mexico and was asked to organize a group of peasants that no one else could bring together.

At the first meeting he stood up and said, "I am here to teach you." Then he sat down. Everyone sat silently for about 10 minutes, waiting to see what he would say next. When he did nothing, someone finally stood up and asked, "Excuse me, what are you going to teach us?" He stood back up and said, "Whatever you want to learn." Then he sat down again. Finally, a woman stood up and said, "I want to learn to sew." Then someone else wanted to learn first aid, and so it went. Porras had someone begin a list of items to learn, then gave the peasants money to go out and find their own teachers and organize their own classes. The cooperative that was founded at this meeting started out with approximately 500 members. Now it has approximately 20,000.

Engineers working in developing countries today have much to learn from the spirit of Nemecio Porras's work. Generally, engineers are trained to put in place physical structures, not to empower people of lower economic status. Yet, without the empowerment of local people, engineering projects in developing countries are bound to fail. Engineers must learn to listen to local populations, working within the social, environmental, and economic context of their projects. This paper is about the practice of socially responsible engineering in the less industrialized nations. It is about engineering in context.

ETHICS OF ENGINEERING IN THE THIRD WORLD—FAILURE AND SUCCESS

The Past

In the past, development for poorer countries has often meant becoming more like industrialized nations. Indicators such as per capita figures for income and energy consumption have been used to describe the quality of life. Such definitions of development need to change so that the goals of engineering projects can be redirected. Much better indicators are found by looking at components of life more intimately linked to the individual—components such as sufficient food, health, housing, longevity, working conditions, access to and maintenance of natural resources, availability of good transportation, community cohesion, and peace of mind.

Traditionally, foreign "experts" would play a role of "all-knowing" authority. Expatriate engineers would sweep onto the scene, designing bridges and other large structures, having very little contact with local communities. Many of the engineer's projects would directly benefit local elites or foreign companies, often intensifying disparities between the upper and lower social and economic status. This same engineer might also hold a government position in the country of residence.

Such conditions still exist in the Third World, but it has become clear that this type of technical assistance does not raise development standards. Development done to or for people does not have sustaining or positive effects. Traditional "hit and run" style projects must give way to development directed by the people whose lives will be affected.

In examining how the engineer from a wealthy country fits into the development of the Third World, a fundamental question arises: Do such engineers have a right to be working in that part of the world at all? I think the answer depends on the capacity and in what spirit they are a part of specific development projects.

It is easy to look at the field of development engineering and say, "Great, just what the nonindustrialized countries need, more engineers frantically building more problematic structures." Underdevelopment comes from a place much deeper than lack of infrastructure. The economic crisis is due to politics, lending policies of international institutions, and poorer communities not determining their future. Becoming an engineer then, would not confront the "real" issues.

Yet, upon further consideration, it can be seen that engineering does not need to be about frantic building. Engineers can be catalysts for people to determine their own future and their own quality of life. Coming from a richer country gives you some unique ways to be of service.

For example, being trained under a comparably well-funded educational system gives you the opportunity and luxury to think about issues that are not always looked at in less developed countries. You have chances to consider people's needs and the preservation of natural resources. Environmental issues in the Third World often take a lower priority because there are other more pressing issues at hand. It is absolutely necessary for these countries to start looking at environmental issues as well, thus we may be well equipped to serve as trainers for Third World engineers interested in this growing field.

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Another situation in which skills can be put to use is when locals cannot afford to hire local engineers. Most often, funding for First World engineers comes from sources outside of the communities that are benefitting from their work. Using that outside funding source, for example, might allow you to put in a road for a farming coalition. Such a road would make it possible for small farmers to carry their produce to bigger markets, bringing more revenue into their communities.

You may not be directly lobbying against harmful development policies of a large aid agency, but if you are using your engineering skills to support the people who are challenging those policies, you are addressing the "real" problem. Your piece to the solution is being contributed through your engineering skills.

Problems with "Expert" Assistance

Many people "doing development," including engineers, have very sincere and generous intentions. Unfortunately, good intentions are not enough to make a project useful to its beneficiaries. There is a tendency to think that anything you might try is helpful and much better than no help at all. Such logic is far from the truth. When a project is harmful or changes nothing for those it is aimed to help, the project has failed.

Projects fail for many reasons. Usually, the underlying problem is that no one involved in the project was able to step back enough to look at the overall context. There is a tremendous need for engineers to look more deeply at what they plan to remedy. Otherwise, their solutions only begin to scratch the surface.

Many engineers have trouble looking at context because they believe that they have an apolitical career—they "just do their job." Despite this attitude, the politics do not go away. One engineer told me of working out of his hotel due to demonstrations in front of his office. People have "disappeared" and have been killed for not approving of large dam projects designed by engineers from developed countries. It would be difficult to put such occurrences in any category other than a political one, whether the engineer recognizes them as such or not. Accepting that development work is, by nature, political, can help the engineer to take responsibility for the overall effects of personal work.

Some of the ways that the big picture is ignored are described next.

Long-Term Effects Overlooked

Projects in developing countries are sometimes built and then abandoned because the long-term costs and other negative effects were not considered during the planning stages. If you plan to build a woodworking shop, does the project generate enough funding to cover maintenance of equipment as well as to pay its workers fully? Will transportation of wood to the shop be too much of an expense?

It is also important to look ahead environmentally and to think about constraints on natural resources in the next 20–50 years. These considerations should be important factors in the environmental design of your project. Looking at the woodwork shop again, it may be good to convert wood into furniture over the next five years. But what happens when too much wood has been harvested from the area? Is that woodworking shop convertible?

Lack of Attention to Social and Economic Context

You don't want to train Third World engineers in the construction of solar panels if no one in the country is going to buy them. What good are the latest in sugar refinery methods if the world market price for sugar has collapsed? When you implement a new water system, what happens to the women who used to discuss the issues of the community while drawing water from the creek? Social and economic shifts should be considered carefully.

Root of "Problem" Not Considered

The problem's root could be no government support for community development. It could also be political strife, lack of education, economic instability due to a world market collapse of the county's one export crop, and so on. These roots must be dealt with if you are to provide more than skin-deep solutions. Band-Aid work quickly falls apart.

Lack of Comprehensiveness in Project Design

If you build a water system to reduce illnesses in a community, it is also important that there is a hygiene education program to complement it. Otherwise, unhealthy practices will continue, and the water system will have done little good.

Too Much Focus on Hardware

Technology can be exhilarating, but getting caught up in its thrill can sometimes blind engineers to the true needs of a community. (More about this issue will be discussed in the appropriate technology section.)

Right Questions about Project Were Not Asked

Asking the right questions will make remedies to problems more clear and thorough. Questions should be asked of people affected by the project, your colleagues, and yourself. Some examples are: Why haven't these people been educated about hygiene and sanitation before? Who should be educating these people and isn't? Why isn't there a system already in place that provides clean water for its citizens? How could these root causes of the sanitation problems be approached, beyond just engineering a pipe system? Who is benefitting from this project? Will old, unjust power dynamics be sustained?

Problematic Attitudes of Foreign Workers

When foreign experts work in undeveloped countries, they sometimes have an elitist attitude. It diminishes chances for feelings of camaraderie and trust to develop between themselves and the local community. Less is accomplished when trust is lacking.

Also, foreign experts will sometimes come to a country knowing very little about the culture. They often make unfair assumptions about the country and may offend individuals or entire communities.

Lack of Attention to Codes of Ethics

Most engineering societies have a code of ethics to which engineers are obligated to adhere. For example, in the American Society of Civil Engineers' (ASCE) code of ethics, canon 1 states that "engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties." There are a number of engineering projects in the Third World, such as the Bangladesh Flood Action Plan (to be mentioned in the section on failed projects), which do not adhere to such codes of ethics. If canon 1 were always followed, such development projects would not be allowed to exist today.

No Evaluations Done

Evaluations are important in that others can learn from your mistakes and use information about what worked. For exam-

ple, a mechanical engineer I interviewed helped a women's group in Africa to design new ovens. He had heard of a technique used in another African country that he thought would work well for his group. However, when he went to get more information, he found that nothing had been written by the aid agency that sponsored the project. Detailed evaluations would have saved him time and money.

It is essential for engineers working in developing countries to remember that they do not need to take on the previously mentioned areas alone. Working in collaboration with people of other disciplines who are trying to remedy similar situations is very helpful. Additionally, of course, listening to the people you want to serve is of utmost importance. They are often your best teachers in determining the most appropriate application of your skills.

Examples of Failed Projects

A computer engineer whom I interviewed lived in Nicaragua during its revolution of the 1980s. He was involved with a project directed by a group from the United States that aligned itself with the government of Nicaragua at that time. The community where the project was located received development assistance for the construction of 18 houses and a water system. The town received aid because it was in a strategic location, on the edge of the war zone. Very little input was sought from the community and, although it was against tradition, the houses were built close together for defense reasons.

Two years later, when this engineer went back, the houses were in extreme disrepair and the water system was no longer in use. Needless to say, he was very disappointed, but at the same time he felt that he had learned some valuable lessons from the experience.

He saw several reasons for the project's failure. The project reinforced old power dynamics—the government organized the community into a cooperative by coercion, then had it directed by an elite group in the village and by the government itself. The coercion came in the form of government-offered incentives, like the development project with which the engineer was involved. The community was never given a chance to develop methods of governing itself. Then, when the government lost power, the new government offered the cooperatives no direction. The people of the community were at a loss and made some poor economic decisions, which caused community funds to run low. When the water system's pump broke, there was no money for its repair. The pump was very heavy, and would have been difficult to carry out; no one in the village owned a car.

The engineer felt that the project would have been much more effective if it had been scaled back and if it were more long term. Also, if the project had been chosen more for reasons of development than for political and military strategy, it may have been successful. Unfortunately, strategy is often a central reason behind development projects. Many people in the community were poor and illiterate. To get to the point where they could tell the government or other outside groups what they really needed would have taken much support and encouragement. Maybe if development workers had established a dialogue with the community, they would have found it better to build some cisterns for catching rainwater. As it was, the community was a pawn for the government, and thus the intentions for the project were not primarily for the people it was claiming to serve.

On a larger scale, projects such as the Bangladesh Flood Action Plan can have much more destructive results. Worth $20 billion in U.S. currency, it is a project sponsored in large part by the World Bank. It consists of an 8,000 km stretch of earthen embankments to control flood effects of the Ganges, Brahmaputra, and Meghna Rivers. Behind the embankments, a system of internal embankments will divide the land into compartments that could be flooded and drained as necessary. Everything should be completed in 20–30 years.

Serious concerns about this enormous project abound, so grassroots organizations in Bangladesh and other parts of the world are challenging its implementation. Some of the problems are as follows:

- At least 5,000,000 people will be displaced, with no plan for relocation.
- Important inland fisheries will be threatened through the blocking of fish migration, as will fish reproductive cycles, which take advantage of flood patterns.
- Bangladesh has very intense, frequent earthquakes, to which earthen embankments are highly vulnerable.
- Such embankments cause rapid deposition of sediments within riverbeds, which eventually causes rivers to be perched above surrounding land. As the rivers reach higher levels, it becomes necessary to raise the embankments—a process that cannot go on indefinitely. Any embankment failure would cause catastrophic flooding.
- The project has been kept secret from people of the area, although some local groups have requested documentation.
- According to one nongovernment organization in the area, the government has controlled criticism of the project through incidents of harsh repressions.
- No comprehensive environmental or social impact assessment, or proposed flood management alternatives have been completed. Despite this, the construction of some pilot projects has already begun.
- Local groups voice concern about the previously mentioned issues, but are ignored. They favored alternatives for dealing with the severe flooding of the area. For example, one proposed alternative is a set of nonstructural measures for flood preparedness. This would be much more effective in reducing flood damage, while preserving the benefits of normal annual flooding (Sklar 1993).

Examples of Successful Projects

Projects have successfully incorporated outside experts when employing the spirit of Nemecio Porras's work: for successful development to take place, people should determine their own destinies.

An organization that has worked successfully to employ this spirit is WaterAid. WaterAid is a group within the British water industry, which works to provide adequate drinking water supplies and basic sanitation in poorer countries. For example, WaterAid cooperated with local nongovernmental organizations (NGOs) in Nepal to construct gravity-flow piped water systems. They provided technical advice and a budget for skilled labor and material. Locals managed their own projects and provided all unskilled labor, paying a small tax (in either rice or cash) to a committee that managed the project. The committee was responsible for maintenance and purchasing of spare parts. All of the parts used were commonly available in the bazaars of Nepal.

Another organization that has done well integrating engineers from industrialized countries is in Ecuador. Organizacion de Pueblos Indigenas de Pastaza (OPIP) is made up of indigenous people from the last remaining virgin rain forest in Ecuador. A U.S.-based oil company is threatening its territory for oil exploration purposes. OPIP is developing an environmental management plan for its territory that uses sophisticated technology such as satellites for forest mapping. Engineers are working with OPIP to combine western and traditional knowledge. The indigenous peoples of this group have received tech-

nological training by engineers in everything from the use of computers and electronic mail to the application of solar energy resources.

Power Dynamics

Sometimes it is obvious what power dynamics you are supporting. It is clear when you are employed by a company that exploits indigenous peoples' lands, without concern for their well-being or for the environment. It is also clear when you are working for an indigenous group on their terms. Unfortunately, it is not always so black and white, and it may take a deeper look to determine what power relations you are encouraging.

For example, let's say that you worked for an organization that has just designed a simple, sturdy, oilseed press, perfect for distribution to small villages in northern Africa. The press should increase individuals' incomes, giving local economies a lift. In one village, you find an individual willing to take over the responsibility of maintaining the press. What you do not know is that this person often befriends foreigners and takes advantage of those relationships to make himself/herself somewhat of an elite in the village. Once you leave, this person starts charging other villagers for use of the machine. This defies the press's original purpose of increasing individuals' incomes. The unequal levels of power are maintained. It would have been much better to talk with all of the villagers to see how they preferred to maintain the press. Maybe they would have wanted to own it collectively. Maybe they would have developed a rotating system of responsibility for its maintenance.

LOOKING CLOSER

It makes sense that there will be differences between working in the Third and First World. Some of the differences are straightforward—using different skills and having a different work environment. Other aspects also exist that are more subtle; policy, appropriate technology, culture, participation, and gender dynamics.

Policy

Engineering in developing countries is intimately intertwined with policies—policies of our home countries, of the organizations for which we work, and of the country in which we reside. These policies influence the choice of projects.

Shaping policy is not an easy undertaking for the engineer. Many policy issues are decided outside of the engineer's sphere of influence, and many funding decisions, including choice of project, are made long before the engineer arrives on the site. Also, engineers working on projects in nonindustrialized nations are expected to reflect the policies of their employer. An engineer, not agreeing with his/her organization's policy, faces the decision of speaking out for the rights of the local population or siding with his/her employer.

There are a few ways for you to avoid this dilemma from the beginning. While searching for a job, it is important to closely examine the policies and practices of potential employers before deciding to become part of their team. Some organizations have more harmful policies than others.

For example, there are projects funded through the World Bank that are quite damaging because they support the economic policy of structural adjustment. Structural adjustment implements an economic austerity plan that focuses on cutting government spending, while orienting the country's economy toward production of exports. Structural adjustment gives little attention to those of lower economic status. This lack of attention negatively affects the well-being of the entire economy. An engineer might be involved in the development of a factory that produces export items. This factory may put small producers out of business, and when the world market for such an item collapses, those benefiting from the factory will be just as bad off as before.

Of course, being selective about the organization or firm for which you work is not so easy. If you are a newcomer to the workforce, you tend to be happy with just about any job. One member of the American Engineers for Social Responsibility (AESR) said to me, "So they've got us, don't they? You can't complain when you're young because you want to keep your job, and by the time you're old, you've been corrupted by the system." I don't believe that this must always be the case. If you don't like the things your firm or organization is doing, there are ways of dealing with it.

Letting higher-ups in an organization or firm know what is happening can often be quite effective. If you do not make it sound like you are trying to shut down the business, you may actually be fairly well received. It is important to convey that your intention is to help the organization do a better job. Most companies want to look good these days—it makes for good business.

Also, organizing some of your colleagues who have similar concerns as you, be it environmental or social, can be effective in ensuring that projects have a positive outcome.

Of course, there is always the alternative of leaving your employer if there seems to be no hope. No worries—you'll find another job.

Appropriate Technology

Technology alone is not the answer to problems of poverty. However, when used in the correct context, it can be an asset for people determining their own development. The important idea is that technology must support power dynamics that encourage the poor's empowerment and prosperity.

Several of the engineers I interviewed agreed that technology is suitable if it passes several of the following socioeconomic tests

- It must be conceptually and physically compatible with the abilities of those responsible for operation and repair.
- Spare parts and equipment must be available for maintenance and repair, which unfortunately often presents a problem with wind and solar technologies. Imported parts are often a challenge to find, or too expensive to purchase. Projects depending on local resources support the local economy and make parts replacement more feasible.
- Financing the project must be within the means of those bearing the cost. If small, local organizations are financially responsible, user fees are often a good way to ensure steady income for maintenance and repair.
- The technology must be compatible with the physical environment where it will be used. For example, you don't want to donate a printing press for use in a humid climate if it cannot tolerate moisture.

Unfortunately, many places in the Third World are graveyards for rusting equipment that wasted development dollars because the technology was not appropriate. If insufficient training is given, or necessary spare parts are too expensive, the hardware goes unused.

It is important to get away from more capital intensive, automated technology. The use of simple, sturdy, labor-intensive alternatives, as well as the use of local equipment and materials, are often much more fruitful. Such an approach provides more jobs, which improves the local economy. This will also lead you, the engineer, to look at some of the broader economic issues affecting your project.

For example, in Pakistan, when they built Tarbella Dam, the largest earth-filled dam in the world, large earth-moving equipment did all of the work while hundreds of unemployed Pakistanis stood by watching. In contrast, Chinese engineers organized 300,000 people to seal, rebuild, and expand the flood protection dikes on the Yellow River.

This is not to say that the transfer of technical skills is not important. Sometimes technical training is the greatest need. Based on a study by Patricia Carrillo of Loughborough University that surveyed a number of Third World engineering institutions, we can see areas whereby engineers from developed countries might effectively transfer skills ("Engineering" 1994). The three lists provided next display technology transfer requests by local engineering groups in the following three regions:

WEST INDIES

- Construction methods
- Contract management
- Hurricane-resistant structures, especially houses
- Improving standards of workmanship
- Maintenance planning techniques

SOUTH ASIA

- Advanced construction methods
- Alternative cost effective building materials
- Construction management
- Cost control
- International project marketing
- Machinery and construction equipment
- Modern materials
- Project management of infrastructure
- Quality control techniques
- Standardization
- Utilizing better tools

SUBSAHARAN AFRICA

- Appropriate technology
- Capacity building
- Construction techniques
- Contractual claims and arbitration
- Equipment/plant management
- Financial control
- Formulation of bids
- Latest design technology
- Low cost and clean energy
- Low cost and mass housing
- Materials
- Planning techniques
- Project management
- Renewable sources of energy
- Structures
- Tending processes
- Use of computers

Table 1, also from the previously mentioned survey, shows effective methods for technology transfer. On the scale, 1 is high in effectiveness, and 5 is low in effectiveness. All numbers in the boxes below the scale show the number of Third World engineering institutions voting for the indicated level of effectiveness in each of the technology transfer techniques. (For example, five institutions voted for "courses in a developed country" as having the highest possible level of effectiveness.)

TABLE 1. Ranking Technology Transfer's Importance (Number of Institutions Voting for Indicated Effectiveness Level)

Technology transfer technique (1)	Scale Value (Extent of Effectiveness) 1 (2)	2 (3)	3 (4)	4 (5)	5 (6)
Courses in a developed country	5	2	—	2	1
Joint ventures with foreign partners	5	3	—	—	2
Technical assistance/cooperation	4	3	3	—	—
Courses/seminars from other professionals	3	5	1	—	1
Access to foreign technical journals	3	2	4	1	—
Access to local technical journals	1	1	3	2	2
Other suggestions	—	—	—	—	—
Develop construction library	—	—	1	—	—
Indigenous research and development	1	1	—	—	—
Careful recording of local practices	1	—	—	—	—
Exchange of professionals between firms	2	—	—	—	—
Distance education	—	1	—	—	—

Note: Scale value of 1 = high effectiveness; scale value of 5 = low effectiveness.

Culture

Cultural differences is one area many engineers might breeze over when considering the challenges of working in developing countries. Don't. Even in the most successful projects, cultural misunderstandings, or a difference in work style, can cause complications.

OPIP has also had such problems, although its projects are generally very successful. Previously, engineers from industrialized countries and other experts gave workshops for OPIP members, but soon realized that nothing was being incorporated into the work. In the United States and in similar countries we are much more accustomed to the traditional classroom setting, with chalkboards and a lecturer. OPIP members are more accustomed to active, experiential learning. After some analysis, OPIP decided that the workshops must be more active in nature. The workshops are now much more successful.

Another cultural difference is management styles. If you find yourself working with a Third World firm, you may be surprised at how many responsibilities you are given. Possibly, you may need approval at points in the project that differ from those in an industrialized country. Standards of professionalism can also vary. One engineer who worked in China told me that it was acceptably professional for Chinese engineers to sit around for a good half of the day, just chatting with colleagues about nonwork-related matters. The management was not concerned.

As far as influencing culture through your projects, I do not think that there is a static culture to preserve. The world is always changing, and so are the needs and desires of people. Just because a group was primarily basket weavers in the past, does not mean that the only right development for them includes basket making. Maybe there are new areas that use their developed basket weaving skills, but are more lucrative for the economy. Perhaps local people would like to use their dexterity to become involved in high-tech electronics production. Asking people what they want is important.

Participation

For projects to bring a higher quality of life, it is best if they are created by locals—with you playing an assisting role. Ask what a higher quality of life means to them.

Sometimes, however, the engineer is responsible for the creation of something beneficial. In this case, community participation is an absolute must.

Be prepared for initial stumbling blocks in this area—par-

ticularly in getting straight answers about the community's needs. When a project is suggested by a donor, people in small, poor communities often go along with the proposed idea, even if it is not exactly what they want. They fear that if they don't take the project they won't get anything at all. It is important to emphasize that expressing true needs will not result in a lack of assistance.

If you are involved in the community's planning of a project, remember that planning is not an event, but rather a process that takes some time. It is time well spent. The planning stage is successful, if it gives guidance for short-term actions and helps shape long-term goals. Projects designed over a longer time frame tend to work much better than short-term assistance programs.

Unexpected Complications

Unexpected complications can be expected in the Third World. Forthcoming are some of the complications that the engineers I interviewed encountered.

Construction materials may not act the way that you expect, due to different standards and style of manufacture from the developed countries. Standards are often not enforced and stamps of approval are sometimes faked. To ensure safety, materials should also be tested, and manufacturers researched. If foreign materials must be used, they should be compatible with local materials.

Also, data that is accessible may not be completely accurate. For example, one engineer had to use 1948 U.S. war maps to get a sense of the geography of a project location. Some maps had no scale, or the scale was completely wrong. Slopes for the land contours were far too extreme, making it impossible to find the desired location on the map. It made error bands greater and the level of uncertainty wider, yet there was no choice but to use this limited information.

Data for rainfall may be scarce. If your project is near a sugar or banana plantation that tracks rainfall, you will have access to more reliable records. If you don't have that information, find out as much about the weather as possible. Remember that monsoons may occur or other extreme weather patterns may exist. Locals may be able to help you refine your assumptions.

Also, you may be misinformed about the project site. The owner may suddenly change the size to be developed. Or, you may be told that it is completely uninhabited land, when, in reality, large numbers of families live there. You then have to find ways to work around them, help them to relocate, or go along with landowners' wishes to bulldoze the site. It starts to become a moral issue, and, once again, a question of power dynamics. To whose wishes do you adhere?

Additionally, lack of infrastructure is common. Therefore, some of the ways in which you might carry out a project at home, even on the simple level of transporting materials, will have to be thought out in more detail. Many developing countries do not have groups that maintain infrastructure, as in industrialized nations. A road may exist, but when a mudslide covers it, there is no one responsible to dig it out. This could happen to a road you build or the water system you develop. In your work, it is important to consider what organization or individual(s) will be responsible for the maintenance of the project after you leave.

Women Engineers

I remember how confused I was about gender dynamics when I worked construction in Central America. I started out very enthusiastically, and I was open to doing all tasks on the site; however, I soon saw that this made the local men feel uncomfortable. They kept taking my work away from me. I do not think that it was meant to be insulting. Rather, I think that they had certain cultural assumptions about women that I did not fit.

I learned a great deal in this situation. First, men and women have different societal roles and assumptions about each other in other cultures that need to be respected. Second, my U.S.-styled feminism was not totally constructive in a Central American context. It often made both men and women feel uncomfortable when they worked with me.

This is not to say that if there are very few women engineers in a country, women should stay home. Instead, it is just important to stay aware, not pushing gender assumptions to an extreme. There are ways that women can be a part of change while working within cultural gender boundaries. Women can sometimes make gender dynamics work to their advantage. Women in developing countries are often more likely to confide in other women than in men. This leads to finding out local women's real needs and goals, and to appropriately helping them to be addressed.

I interviewed one women engineer who worked in Ghana for several years. She said that she was not treated differently in Africa because she was a women. In fact, she had many more problems when she worked in the United States. In Africa, she was unusual because she was Caucasian, not because she was a woman. She said that she thought it may have been different if she had been an African woman. Assumptions about her abilities as an engineer have been more frequently made in the United States than in Ghana.

GETTING STARTED

How do you get started in this kind of work? International engineering jobs are not usually advertised in the want ads. It helps to have the ability to create your own opportunities. A solid education is important, as is overseas experience.

Organizations Doing Development Work

Let's start by looking at the types of organizations with which you might work, such as the following:

- Small, local, nongovernmental organizations (NGOs)
- Private voluntary organizations (PVOs)
- Governmental agencies of the country where you are working
- Bilateral aid agencies
- Multilateral donors
- Multilateral lenders
- Local private firms
- International private firms

I wish it were easy to categorize these groups, knowing which ones will be doing good things, and which ones may be causing damage. So much about an organization's projects depends on the individuals who comprise its staff. If you ask the right questions, the nature of a group's work should become clear to you.

Keep in mind that the larger the organization, the more power and money are involved in decision making. This means that your voice can often get lost, and you may find that compromise is a daily necessity in such jobs. The smaller organizations may be more open to your ideas, even if your concerns are not profit oriented. Choosing the right organization for you is delicate and involves carefully weighing your needs against the priorities of your potential employer. It is not so simple as "big agencies are bad" or "small NGOs are good." Infiltrating the problematic companies and pushing for a more conscientious agenda can be just as important as supporting those smaller organizations that already reflect your ideals.

Education

The engineering education on its own tends to be narrow. It is technically specific and does little to teach how engineering can be done with a socially responsible perspective. Therefore, combining your education with another degree is often very helpful. Some universities offer special five-year programs for engineering students who wish to get a second bachelor's degree. The other degree can aid in preparing you for the work environment of a developing country. Some possible complementary degrees include degrees in economics, public health programs, environmental studies, development studies, and energy resource management.

Mentors

An invaluable tool for turning vague ideas about engineering in context into focused visions is found by looking at, and talking to, those who are thriving in the field. If you are just starting out in the field of development engineering, I would encourage you to seek out those who do your "dream" job and to conduct informational interviews. A few examples follow concerning the people I found who are successfully combining social responsibility and their engineering skills.

A civil engineer I interviewed worked for many years with the PVO, Catholic Relief Service (CRS), in Latin America, the Caribbean, Eurasia, and Africa. He got this job by contacting CRS, then dropping off his resume and master's thesis. About 25% of his time was spent in the field, conducting on-site inspections of projects and providing technical support to local staff. He reviewed and approved all engineering-related projects for CRS, assessing both technical and economic feasibility. He monitored the progress of projects both financially and technically. In addition, he developed policies and project guidelines for water supply and sanitation undertakings.

What made his work most successful was the integration of nonengineering knowledge into the understanding of water supply projects. There was very little focus on traditional engineering practices. Projects he found to be successful had much community involvement, a comprehensive nature (i.e., health education, administrative training, as well as operation and maintenance planning), and a strong commitment by the organization doing the work.

Now he is the executive director of a nonprofit organization called WaterPartners International. This NGO does not design or implement projects, but rather focuses its efforts on (1) raising public awareness of the immense problems caused by unsafe and inadequate water supplies in underdeveloped countries and (2) raising funds for the construction of drinking water supply projects in developing countries. They support organizations implementing water systems that incorporate a community-centered philosophy.

I interviewed a woman engineer who holds a B.S. degree in engineering and environmental science from Rutgers University and an M.S. degree in energy management for development from the University of Pennsylvania. She served for two years in Ghana in the Peace Corps, using her engineering training.

She is manager of renewable energy programs for the United States Agency for International Development (USAID) Office of Energy, Environment, and Technology's energy training program (ETP). Her primary responsibility is to manage and implement environmental and renewable energy training programs for ETP. This includes designing and developing U.S.-based study tours, long-term training courses, and in-country workshops. She initiated courses focusing on topics such as environmental management, air pollution control technologies, stationary source and ambient air pollution monitoring, and environmental policy development and implementation. She has traveled extensively for ETP to determine energy and environmental training needs in the third world, and her regional areas of expertise are Africa and eastern/central Europe.

Additionally, I interviewed a civil engineer who previously worked as an environmentalist, until he realized that engineers had information that he was always seeking—thus, he turned from an environmentalist into an engineer with environmental awareness. He is now a civil engineering associate at a small engineering firm, Philip Williams and Associates (PWA) Ltd., in San Francisco. He is also the chapter coordinator of American Engineers for Social Responsibility in the Bay Area. PWA offers consulting services in all aspects of hydrology, hydraulic engineering, geomorphology, and water resource planning. Presently, he is involved with two international projects; one in the Philippines, and one in Indonesia. His company has been hired as an environmental consultant to ensure that the environment is protected during design and development of the projects. In the Philippines, the project entails the development of a new city to relieve urban migration pressures on Manila.

Conclusion

Repeatedly emphasized by engineers in the field is the importance of developing a specialized skill for working in poorer nations. Discovering your area of potential expertise, however, is not always easy. Usually, you need some hands-on experience before you can be certain of areas you enjoy and excel in.

If you are still a student, co-op education programs or summer jobs can provide you with needed experience and opportunities for skill building. These types of programs are somewhat difficult to find overseas, although finding them is not impossible.

Volunteer programs and work brigades are also a possibility for gaining experience and are more likely to take you into small developing country communities. One possibility for finding such volunteer opportunities is to seek out a directory of development organizations, contacting groups listed for information about internships and volunteer opportunities. Phone calls or faxed resumes will usually draw a faster response than will inquiries via mail.

Whichever method you choose to gain this hands-on experience, it will most definitely serve you well. You will better see how your skills can be used to serve people in developing countries. You will learn first hand how important socially responsible engineering is in the Third World. You will learn how to engineer in context.

APPENDIX. REFERENCES

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