

**AC 2007-239: ENGINEERING AND THE OTHER AMERICA**

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# **Engineering and the Other America**

## **Abstract**

In the present work, the growing awareness in engineering of the responsibility towards the poor is considered. The following approach is taken: a brief overview of the issues of poverty particularly in the U.S. is provided; and recent developments in engineering related to the issue of poverty are discussed. The purposes of the work are: to bring an awareness of the plight of the poor that live here in the United States; to point to some new efforts in engineering and engineering education that begin to address our responsibilities towards the poor; and to encourage a vigorous and ongoing conversation focused on our responsibilities as engineers and educators towards the poor.

## **Introduction**

Engineering and its product, technology, hold immense promise and unlimited potential for all of us who share our destinies on planet Earth. Each of us can imagine a time in the future at which all of the world's dreaded diseases are eliminated, there is abundance for all and each of us can live our life to its maximum. No doubt it will be the problem solvers of society, the engineers, who will be called upon to get us to that point. The question then becomes will engineering as we presently know it enable humankind and all of creation to fulfill that dream? My response to that question is no, not as engineering is practiced today at the beginning of the 21st century. While engineering is a profession with a strong ethical dimension, and while we have explicitly stated in our various codes of conduct that we must hold paramount the public safety, there has been until very recently no reference to addressing two of the most important issues of our times – poverty and underdevelopment and environmental degradation. It is as if engineering as a profession is somehow excused from such deliberations or that if we serve our employers faithfully and professionally, it will somehow all work out in the end. I do not believe it will somehow work out in the end but rather believe that we, as engineers, need to change the way we envisage our profession. The present work will limit the discussion to the case of the poor within the U.S.

## **State of the Poor**

We are confronted daily with growing evidence of the deteriorating health of the Earth's ecosystem. Unfortunately, such evidence of environmental deterioration is only the tip of a much more dangerous problem: the growing inequities in wealth and income between countries and within countries, inequities that will generate enormous social unrest and pressure for change. Moreover who would deny the reality of starving people in Somalia, India, or other countries which are desperately trying to cope with millions of homeless, landless people? According to the most recent estimates, six billion people now exist and seven billion are expected by the year 2006, nearly eleven billion by 2045.

Over 79 percent of humankind lives in the immense and poor southern hemisphere; one billion people live in the state of absolute poverty; over three billion do not have enough to eat, sixty million die of hunger every year; and fourteen million young people die each year as a result of hunger-caused diseases.<sup>1</sup> There is practically no consensus view on how to deal with the poverty issue. The United Nations has challenged the world's wealthy countries to earmark 0.7 percent of each nation's Gross National Product (GNP) for aid to the needy countries. Tragically, the richest country, the United States, devotes less than 0.15 percent of its GNP.

### *The Visible Poor*

It would be easy to dismiss the problem of poverty to those not fortunate to be born in the United States. In fact, in the United States fully 12.7 percent of the population (i.e. nearly 40 million people) - the highest percentage in the developed world – lives in poverty. Each year since 2001 the number in the U.S. that lives in poverty has grown.

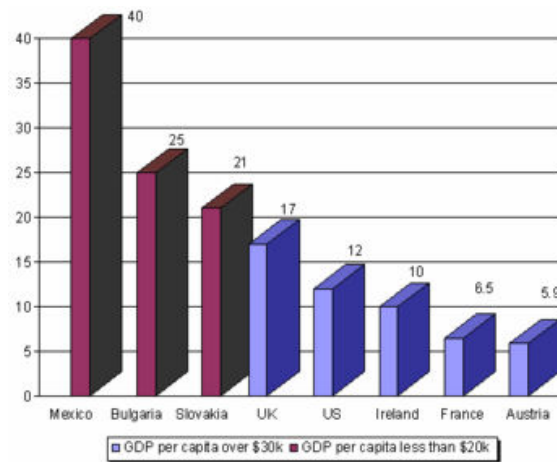


Figure 1 Percentage of Population below the Poverty Level<sup>2</sup>

Since January 2004, an additional 5.4 million have slipped below the poverty line. Poverty in the U.S. is a far different and more complicated phenomenon than our traditional understanding affords us. Most people who live below the poverty line have jobs. In fact, many families have members with two jobs. In the U.S. today, countless families, even those with two working parents, frequently fall below the poverty line for both short and long periods of time. The minimum wage of \$5.15 an hour has not risen since 1997 and, adjusted for inflation, is at its lowest since 1956. There is a growing gap between those members of society who count themselves among the 'haves' and those who are part of the 'have-nots.' In 2004, 45.8 million Americans lacked any health insurance. Also in 2004, the top 20 percent of earners took home over half the national income while the bottom 20 percent earned approximately 3.4 percent of the national income.

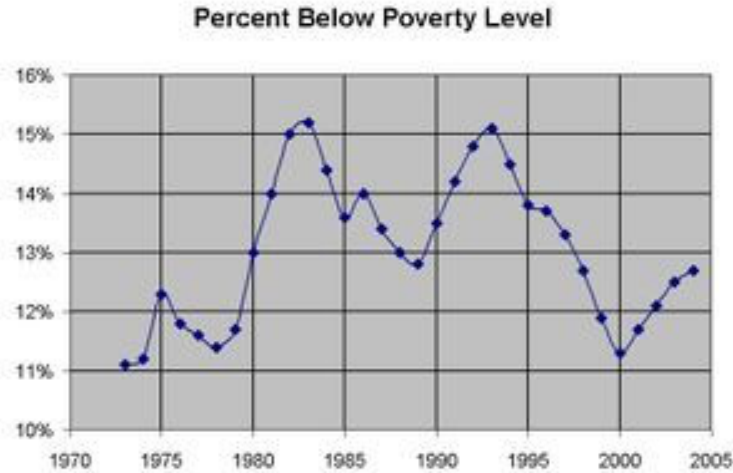


Figure 2 Percentage of U.S. Population below Poverty Line<sup>3</sup>

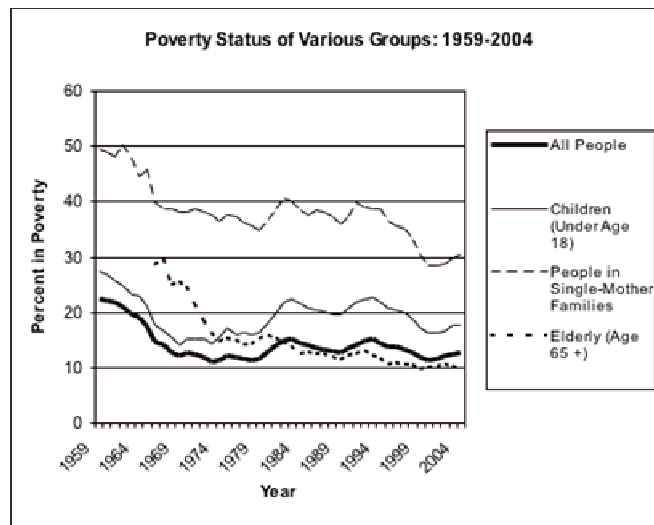


Figure 2 Percentages of Various Groups that Live below Poverty Line

While there are 39 million Americans living below the poverty line, the United States has 269 billionaires, the highest number in the world. Almost a quarter of all black Americans live below the poverty line; 22 percent of Hispanics fall below it while for whites the figure is 8.6 percent. There are 82,000 homeless people in Los Angeles alone.

In 2004 the poorest community in America was Pine Ridge Indian Reservation. Pine Ridge Indian Reservation is an Oglala Sioux Native American reservation located in South Dakota. Pine Ridge was established in the southwest corner of South Dakota on the Nebraska border and consists of 8,984.306 km<sup>2</sup> (3,468.86 sq mi) of land area, the eighth-largest reservation in the United States, larger than Delaware and Rhode Island combined.

Unemployment on the Reservation hovers around 85% and 97% live below the poverty line. Average annual family income is \$3,800 as of 1999. Adolescent suicide is 4 times the National average. Many of the families have no electricity, telephone, running water, or sewer. Many families use wood stoves to heat their homes. The population on Pine Ridge has among the shortest life expectancies of any group in the Western Hemisphere: approximately 47 years for males and in the low 50s for females. The infant mortality rate is five times the United States national average. In the Western hemisphere only Haiti has a lower life expectancy.

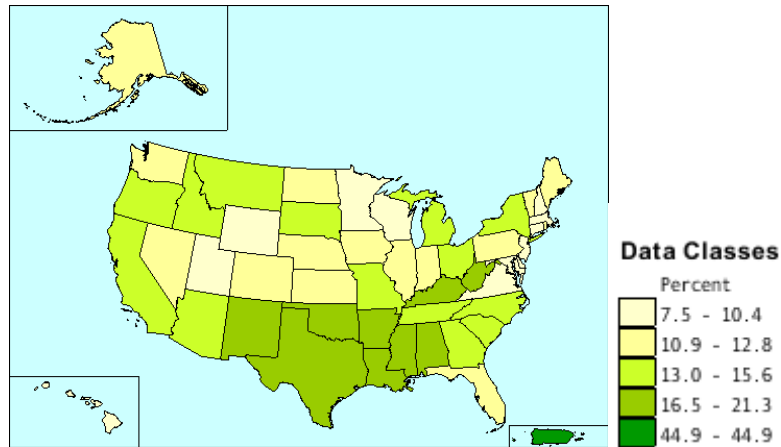


Figure 3 Percentages below Poverty Line by State (2005 U.S. Census)<sup>4</sup>

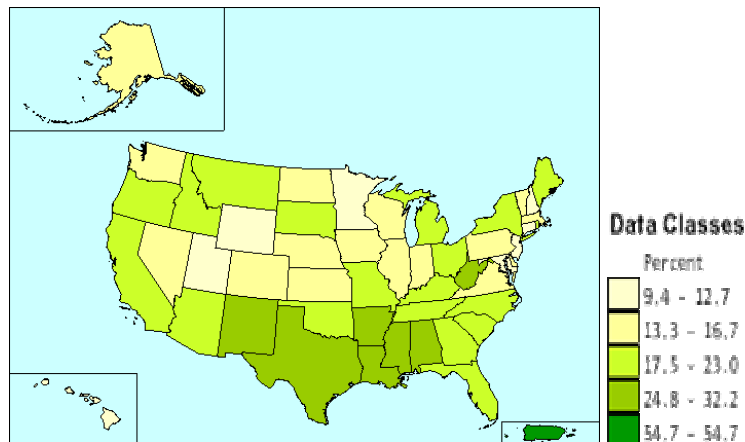


Figure 4 Percentages of Children in Poverty by State (2005 U.S. Census)<sup>5</sup>

The standard of living in the United States is one of the top 15 in the world by the standard economics-based measure of standard of living. Average income per person is high but also less evenly distributed than in most other developed countries; as a result, the United States

fares particularly well in measures of average material well being that do not place weight on equality aspects.

On comprehensive measures such as the UN Human Development Index the United States is always in the top ten, currently ranking number ten, though generally ranked lower than the Scandinavian countries, Ireland, Belgium, Canada, Australia, and (until recently) Japan; Canada and Norway have alternately held the top spot for some time. On the Human Poverty Index the US is ranked worst among the selection of 17 wealthiest countries, scoring poorly on all counts but long term unemployment.

While the United States' mean wealth is one of the highest of any major country, most of the wealth in the United States is held by the upper middle and upper class. While the median income is \$43,318 per household,<sup>6</sup> there is an unequal income distribution.

The United States has more people below the defined poverty line than 26 other advanced countries; however, the measures used to establish a poverty line are controversial and may not always be comparable among countries. What is clear, however, is that the United States has the widest rich-poor gap of any high-income nation today, and that gap continues to grow.<sup>7</sup> The ten percent of Americans with the highest incomes earn 15 times more than the bottom ten percent. In Japan, for instance, the ratio is only 4.2:1. While the exact reasons for this extent of economic disparity are complex, some analysts and critics regard the imbalance as a product of the United States' long policy of having more of a free market economy, while other countries have enacted policies which may sacrifice net wealth in favor of economic equality. However, this argument is inconsistent as Ireland has the third most free economy in the world, according to the Index of Economic Freedom. In recent times, some prominent economists including Alan Greenspan have warned that the widening rich-poor gap in the U.S. population is a problem that could undermine and destabilize the country's economy and standard of living.<sup>8</sup>

According to recent estimates, almost 25 percent of the U.S.'s counties had low per-capita incomes below one half of the national average or less, high unemployment, low labor force participation, and a high dependency on government transfer payments, all of which are measures of economic distress. The problem of persistent poverty is a complex one that includes communities and individuals who through no fault of their own, find themselves unable to make ends meet in this globalizing, information-intensive world. People at risk are women, children, the elderly, people of color and single-parent families. Large numbers of the nation's citizens live at or below the poverty threshold, struggling to pay bills and provide the basics of food, clothing and shelter. Health care and simple comforts are beyond the means of many of our fellow citizens.

America's poor people are people who work or who are dependents of people who work and face limited opportunity often due to living in places that are seriously disadvantaged because of geography or history or both. Though progress has been made since the late 1950's and early 1960's when over 20 percent of the nation lived below the poverty line, if anything, the gap between the economically secure and the poor is more severe than it was four decades ago. Increasingly, there are two nations: one is composed of people who look

to a future in which circumstances include the expectation of more wealth, security and opportunity; and the other is a nation who struggle to make ends meet.

There has been some progress in the responsibility of engineering for the eco-system. Unfortunately for the poor, there have been virtually no parallel developments in extending the ethical responsibilities of the engineering profession. The poor have been conspicuously absent in nearly all conversations. Harrington described the *invisible poor* in his landmark study of poverty in the United States. Though not intended solely for the engineering, that description of the poor in the U.S being *invisible* seems incredibly accurate though deeply troubling for our profession today.

### *The Invisible Poor*

In *The Other America*, Harrington's describes the egregious conditions under which what we would now call the "underclass" lived in mid-20th century American society. Few works of contemporary non-fiction have had more lasting impact on the social consciousness of the U.S. society. Harrington detailed realities of life for those many millions of Americans of both color and ethnicity living lives of desperate poverty in the midst of the affluent society. Millions of readers, myself included, were shocked to discover the extent to which this world coexisted with our own, and many of the social action programs that arose in the 1960s and thereafter used this book as a kind of reference guide to the realities of poverty in contemporary society. Indeed, what is most disturbing for anyone re-reading the book is the realization that few of the conditions have changed for those who through the accident of birth, color, and ethnic origin, find themselves inexorably trapped in the vicious cycle of poverty.

Sadly, the sobering truth is that very little progress has been made. Indeed, in more recent books such as Finnegan's *Cold New World*<sup>9</sup>, Harrington's basic thesis of the co-existence of a starker, poorer, and powerless populace left stranded to *live lives of quiet desperation* is reconfirmed, putting the lie to the many proclamations of universal opportunity and promise that so many U.S. politicians routinely pronounce. Harrington's fundamental argument is incontrovertible; poverty is extensive and endemic, and is usually hidden from the view of most affluent Americans due to the ways in which the two subcultures coexist in modern society. Through the de-facto residential segregation of the two elements of the society, there is little meaningful contact. In addition, the media tends to ignore the facts of the existence of the underclass, portraying arch-types which conform more to the sensibilities of the more affluent segments of the society that regularly view its programming and enforcing unrealistic images of what exists. We no longer habituate the same environments, and we tend to avoid all unnecessary contact with anything to do with the world of poverty and want. Harrington wished to ignite America's slumbering conscience. What Harrington originally described in such stark terms has instead become a permanent feature of our conscience-less socio-cultural landscape. Despite the history of the social legislation that attempted to rework this problem in the decades during the four decades since, the reality of the situation seems to be that nothing much has changed in terms of the life-chances and hopes of the members of the underclass.

Unfortunately, there are likely many additional members of our society who live in poverty. The poverty line is dependent on income as a measure of sufficiency and is based on gross earnings before taxes. It is unadjusted for differences in costs of living among different places. It still assumes that families spend one third of their income on food which is no longer the case. Today food makes up approximately one sixth of expenditures; housing, transportation and utilities are a much larger percentage of expenses than was the case in the 1960's. Other expenses such as child care, critical in today's households, are not included, suggesting that the official poverty measure understates the minimum level of income families actually require.

### Changes in Engineering

Engineering is beginning to experience some changes which point to a heightened sensitivity both to the destruction of the Earth as well as to the plight of the poor. Modifications to existing codes are being suggested though their widespread adoption seems to be much farther off into the future. New disciplines within are beginning at various institutions in the U.S. and in Canada. New professional organizations have been launched modeled in part after the *Doctors without Borders* effort though the engineering organizations tend to focus on a greater involvement of undergraduate students. Lastly, new learning paradigms which integrate community service are being implemented and evaluated.

### *Codes of Conduct*

Professional engineering societies' codes of ethics declare that engineers have a fundamental ethical obligation to hold paramount public health, safety, and welfare. Recently, there has been growing debate as to the limits if any of this obligation. Does the obligation to practice harmoniously with the welfare of the public include an obligation, for example, to reduce world poverty? Should engineers be responsible for trying to eliminate poverty?

According to capitalism, economic growth is a key driver of economic prosperity and, thus, is essential to reducing poverty. But it also is recognized that growth at any cost generally is not sustainable. Even advocates of this perspective note that responsible growth--growth that embraces both environmental sustainability and social development--is what really may be required to reduce poverty. If sustainable development is to have any meaning, engineering societies and other segments of the engineering profession will need to promote the importance of sustainable development among practicing engineers.

For example, representatives of the National Society of Professional Engineers (NSPE) added language relating to sustainable development to the NSPE Code of Ethics for Engineers. NSPE members believed their code of ethics should include a provision that recognizes an engineer's obligation to perform professional services compatible with basic principles of sustainable development. At least two other national engineering societies have amended or supplemented their codes of ethics to incorporate principles of sustainable development. Following careful study, participants in NSPE became convinced that



implicit in the obligation to hold paramount public health and safety is the responsibility to practice consistently the principles of sustainable development.

NSPE members previously had considered a similar recommendation. The NSPE Board of Directors rejected the recommendation largely because of concerns that such language could be used to hold professional engineers to a standard of care higher than the one legally required. However, following a period of study, the NSPE membership moved the proposal forward, approved it without debate, and accepted the following language for inclusion in the NSPE Code of Ethics for Engineers:<sup>10</sup>

*Engineers shall strive to adhere to the principles of sustainable development in order to protect the environment for future generations.*

"Sustainable development' is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development"

While changes to professional societies' codes of ethics send an important message to the profession, individual engineers ultimately will need to become actively engaged in understanding the problems facing developing nations and designing solutions to overcome the challenges. Advocates of this new perspective for engineer note that not only is it a matter of professional ethics that engineers help the developing world; it is a matter of enlightened self-interest. As the world's problem solvers, engineers have a special role to play.

A different approach taken in the effort to include the poor and the environment in a professional engineering code has been described by the author. *Engineering Ethics: Peace, Justice, and the Earth*<sup>11</sup> offers a new ethical foundation for the engineering profession. Modern engineering codes of ethics have primarily been developed using a Utilitarian approach. The author adopts Johnson's morally deep world view<sup>12</sup> from a deep ecology perspective in environmental ethics as the basis for engineering practice. The fundamental canon of the new code of ethics is the following:

*Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health and welfare of the identified integral community.*

The key difference between the new code and existing codes is in the inclusion of an identified integral community. Several case studies are examined in light of the new code including the development of new tools for Mexican farmers, the design and fabrication of devices for the physically challenged, the mechanization of grape-picking in California and the development of transportations systems for the tourist industry in Churchill, Ontario, Canada. Using the new ethical code, a design methodology is developed based on the implicit notion of promoting justice and peace and reducing suffering. Implications of these developments for engineering education are also explored with a new paradigm for engineering education based upon the Integral Model. The most significant change that

results from an adoption of the morally deep world view in the design methodology is that one requirement that is specifically outlined is in the form of the following question:

*Has the suffering and/or injustice in the world been reduced through the completion of the proposed engineering project? If it has not, the project and solution should not go forward. If it has, the solution is morally and ethically acceptable.*

The asking of such a question, the insistence on such a criterion, represents an important broadening of the sense of responsibility that engineers have in their proposed solutions to open-ended problems.

A recent article by Singleton<sup>13</sup> focused on poverty alleviation and the role of the engineer. According to Singleton, community infrastructure is the key to alleviating poverty and engineering and engineers have an essential role to play. Engineering solutions are integral to mitigating poverty; however, engineering is not the sole contributor to successful poverty alleviation programs, which also entail attention to social, economic, and political influences. Sustainable engineering will be achieved when the engineering solutions adopted take into account their use of natural resources. Optimum solutions will have a positive or neutral impact on natural resource consumption. Unsound engineering solutions, by comparison, may leave the environment depleted and society poorer over time. Sound engineering solutions to poverty alleviation has three main components:

- *Life-cycle engineering* takes into account the operational and maintenance cost of the engineering solutions proposed, such that the completed projects have effective and affordable operational and maintenance regimes.
- *Empowered engineering* will take into account the capabilities of the local community, particularly its engineering and technical professions. Where possible, the solutions developed will involve local professional and technical staff and will establish an on-going engineering and operational resource.
- *Appropriate engineering* will consider various options that meet the engineering needs of the project and may adopt techniques of labor-based construction, which differs significantly from labor-intensive construction. The latter basically substitutes men for machines, e.g. constructing a concrete-framed building where the concrete is mixed by hand without a mechanical mixer. Labor-based construction, by contrast, aims to change the technology involved to what is appropriate for manual labor, e.g. eliminating the concrete frame and building the structure of load-bearing masonry. Labor-based construction has been shown to compare favorably with plant-based construction<sup>4</sup>. In addition, it facilitates knowledge transfer, creates jobs, encourages private enterprise, creates ownership, and may reduce cost.

*New Organizations*

- *Engineers without Borders - USA (EWB-USA)* is a non-profit humanitarian organization established to partner with developing communities worldwide in order to improve their quality of life. This partnership involves the implementation of sustainable engineering projects, while involving and training internationally responsible engineers and engineering students. *EWB-USA* contributes to meeting the United Nations Millennium Development Goals (MDGs) through capacity building in community projects. Capacity building is defined in that context as “...the building (or strengthening) of human, institutional and infrastructure capacity to help societies develop secure, stable and sustainable economies, governments and other institutions through mentoring, training, education, physical projects, the infusion of financial and other resources, and most importantly, the motivation and inspiration of people to improve their lives.”<sup>14</sup>

A second group, *Engineering without Frontiers (EwF)*, based in the United Kingdom, also focuses upon the issues of environmental degradation and poverty. EwF examined how engineering should understand and respond to society's expectations, sustainability and to the challenge of achieving the Millennium Development Goals (MDGs).

*EwF* produced a set of 'Principles for Development Engineering' outlining the attributes required of successful development engineering as they relate to Social Justice, Sustainability, Appropriate Standards, Capacity Building and Knowledge, Delivery and Procurement, Outcomes and Context. These completed principles were communicated to the G8 summit to highlight the importance of the engineering contribution to development.

*Engineering for Developing Communities, EDC*, is relatively new educational research and outreach program at the University of Colorado which claims to present both a long term solution and unique opportunity for educating future engineers who are “capable of contributing to the relief of the endemic problems afflicting developing communities worldwide.”<sup>15</sup>

*Engineers in Technical Humanitarian Opportunities for Service, ETHOS*, states as their purpose to “facilitate research and the development of appropriate technology by forming collaborative North-South partnerships between universities, research laboratories, engineers and non-governmental organizations in foreign countries.”<sup>16</sup>

#### *New Pedagogy: Service Learning*

A new pedagogy which has been gaining increasing attention across the university particularly in engineering is a form of experiential education known as *service-learning*. Service-learning is a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities and thus may be an important mechanism whereby engineering education may begin to address issues of environmental degradation and poverty.

One of the most important and innovative service-learning efforts is named *EPICS*.<sup>17</sup> *EPICS*, started at Purdue University in 1995, stands for Engineering Projects in Community Service. In the program, teams of undergraduates earn academic credit with multiyear, multidisciplinary projects that solve engineering and technology-based problems with community service and education organizations. This partnership provides many benefits to the students and the community alike. For example, *EPICS* teams have developed projects ranging from homelessness prevention to environmental protection to creating toys for children with disabilities. The teams are: *multidisciplinary* – drawing students from across engineering and around the university; *vertically-integrated* – maintaining a mix of freshman through seniors each semester; and *long-term* – each student participates in a project for up to seven semesters. The continuity, technical depth, and disciplinary breadth of these teams enable delivery of projects of significant benefit to the community.

*EPICS* goals are given as:

- Broaden students' education to include experience with design as a start-to-finish process by defining, designing, building, testing, deploying, and supporting real systems
- Bring affordable engineering expertise to community service and education organizations

Engineering as a profession with an ethical dimension now is firmly and fully embraced by professional societies, engineering organizations and institutions of higher education. Nearly all disciplines within engineering have published codes of conduct which outline what each refers to as the behavior of an ethical engineer. In addition, there is a growing awareness of the importance of educating tomorrow's engineers on issues related to environmental impact. Some engineering societies, notably ASCE explicitly list *sustainability* as an important criterion when making engineering project decisions. Perhaps the strongest proponent of a careful integration of ethics into engineering is the Accreditation Board of Engineering and Technology (ABET). In Criterion III,<sup>18</sup>

*...the need for a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*

is clearly stated as an important requirement for engineering programs.

As has been discussed there is increasing awareness within the engineering profession to consider the impact of technology upon the environment. Until very recently, there has been little if any effort to consider the plight of the poor. Unfortunately for those who live in the U.S., most of the increasing sensitivity directed towards those who live in poverty is directed overseas. The new educational paradigm, service learning, and the focus on community service and the engaged university does hold promise for an inclusion of the needs here at home in our ghettos, rural areas and Native American reservations. Hoping

for an increased sensitivity to the poor that dwell here among us is one of the main reasons for writing this article.

### **Concluding Thoughts**

Engineering has not single-handedly changed the Earth's ecosystem but it has played a role. It has only been very recently when any engineering discipline has paid any attention at all to the impact a proposed engineering solution will have on the environment. Yet even today, the number of engineering professional societies and organizations that pay even a modicum of attention to environmental impact is relatively small. Too often environmentalists as well as environmentalism are considered nuisances. Codes of professional conduct may call routinely for serving the public good but rarely speak of the health of the natural world. Even when Nature does make it into the discussion it is a Nature which can be best characterized as a collection of resources. McDonough<sup>19</sup> refers to this approach to problem solving in the professions as "being less bad." We can feel good about ourselves as the society's problem solvers if we produce less toxins or hazardous waste or contribute to the Earth's warming a little less rapidly. Then as a result, the numbers of polar bears will not dwindle as quickly as they would have if we had not been quite so good. In my view, "being less bad" is no longer sufficient. McDonough and Braungart argue for the *Next Industrial Revolution*<sup>20</sup> in which taking nature's operating system as their model, industry, products, and buildings are designed to be as safe and renewing as natural processes.

The historical record of engineering and its sensitivity to the plight of the poor is even more troubling. It has only been very recently that any mention of the poor has made it in the engineering classroom at all. New organizations are starting such as *Engineers without Borders* and *Engineers without Frontiers* which brings the classroom face-to-face with some of the most impoverished parts of the world. New disciplines such as for example *humanitarian engineering* are beginning as well which focus on similar issues. Service learning as a learning pedagogy which focuses upon serving the community outside the campus gates is becoming more visible in engineering as well, most notably through the efforts of the program. Recently, the National Society of Professional Engineers has been considering identifying alleviating poverty as part of the professional and ethical responsibilities of engineers. Each of these new developments points to an exciting new direction for engineering and must be complemented. My hope is that rather than being the notable exceptions, such organizations, disciplines, learning strategies and codes of conduct will become much more widespread.

The engineering failure of the flood wall system in New Orleans had devastating consequences for the residents of the Big Easy, the State of Louisiana and for the nation as a whole. Tragically as happens far too frequently, the residents who suffered the most were the poor, those who lived in the 9th ward and similar sections of the city, who had few options for evacuation. Engineers and engineering organizations let them down. I submit that says more about us as a profession than it does about them. Borrowing from Harrington, the poor of our own nation have been invisible for too long, certainly invisible to engineering and the engineering education. Our sensitivity to their condition must go far

beyond a perfunctory listing of alleviating poverty as an entry item on a checklist for design criteria alongside manufacturability and serviceability. No, I am not arguing for another item to be included in a revised ABET<sup>21</sup> set of criteria though that would be a tremendous help. Rather, I submit that within each of us, all of us, there resides potentialities and possibilities which must not be wasted or taken for granted or ignored.

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