Engineering Culture, Sustainability and Humanitarian Engineers

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***Abstract* —** *Engineers are in a unique position to make a difference in the world. They have the skills and knowledge that can change environments, improve basic systems, and the ability to solve complex problems. Today's graduates often embody and give credence to a paradigm shift in engineering culture. Engineering culture has long been thought of as technologically driven, problem solving professionals. Today's graduates, the products of 24/7 global news and information coverage and exposed often to the concept of "sustainability" are the forerunners of what may be a profound change in the way engineering cultures and practitioners affect the world. Colorado School of Mines and numerous other universities and organizations are interacting with their clients in a way that recognizes connections, modifies behaviors and identifies opportunities for addressing problems where traditional structures and behaviors are at odds.*

***Index Terms* —** *culture change, engineering culture, sustainability,*

The engineering culture paradigm has begun to shift; engineering students are graduating with the broad perspective so eloquently articulated by Dr. Robert E.D. Woolsey, Emeritus Professor of the Colorado School of Mines, *". . . the ideal that pure technical problems do not exist- only those embedded in political, cultural, ethical, and moral problems. Our purpose is to produce a graduate who will both know and act on this reality."* [1] Our students and faculty are the products of 24/7 news and information cycles. Our students explore "Facebook", watch "YouTube" and "Twitter" with abandon. They, along with the faculty who teach them are exposed routinely to the concept of "sustainability" and they are leading the paradigm shift in engineering cultures.

Woolsey comments were from 1978 and reflected a perspective that was very much different from earlier perceptions of engineering culture. Palmer Rickets observed a century earlier that engineers graduated with "a smattering of so called practical knowledge,. . . .turning out surveyors, and those of mechanical engineering, mechanics, rather than engineers." [2] The engineer of the time graduated with a sense of purpose, to solve technical problems, with skill sets that would let him build bridges or buildings, move water and design the gizmos and gadgets that would make life easier or better. In the main, he was product and technologically focused.

Almost a decade later, Bordogna lamented that "engineering curricula usually presented the set of topics engineers "need to know," leading to the feeling that an engineering education is simply a collection of courses [that] ignores the need for connections and integration." [3] This concern was repeated throughout the literature on engineering culture about the universities that provided the courses an engineer would need to master if he was going to be called on to solve problems. The criticism was that they often failed to provide a social, political or economic context.

The shift probably began to take on importance in 1989 when the National Science Foundation published a list of essential capabilities and skills for engineering graduates: The graduate needed to be able to integrate, analyze and synthesize information "supported with sensitivity to societal need and environmental fragility" [4] The report went on to imply that engineers were the leaders who should be able to appreciate "the economic, industrial and international environment" of engineering practices in which they would work. NSF was calling for a cultural paradigm shift.

The idea that problems need solutions and engineers have the knowledge and skills to provide solutions is reflective of an older, often stereotypical, perception.. Engineering culture embodied the idea that solutions are always possible, anything can be built or modified, or created with talent. The problem, if there was one, was that people could get in the way of perfectly fine solutions.

John Prados, Emeritus Vice President, University of Tennessee, in 2006 characterized the weaknesses of engineering graduates including "technical arrogance, no understanding of the manufacturing process, lack of design capability or creativity, lack of appreciation for considering alternatives, all want to be analysts, narrow view of engineering and related disciplines, no understanding of the quality process, weak communication skills and little or no experience of working in teams." [5]

In 2001 at the ICEE, Baba and Pawlowski observe "While engineering education scholars and industry leaders agree that cultural transformation is called for, there is neither widespread understanding nor agreement about how to change

academic culture when one of academia's characteristics is conservatism and a generally high level of resistance to change." [6]

But, engineering culture has changed and is changing and the question for an anthropologist in the midst of scientists and engineers is can we identify the catalysts that have prompted these changes. Anthropologists study people as members of groups, using a technique called participant observation. I have been privileged to work with and teach some of the brightest young adults pursuing degrees in the diverse branches of science and engineering. I have met faculty who are energized by the breadth of global awareness of their students; inspired by their desire to do well by doing good and committed to provide the context through design courses that include consideration of the broader community. Many students today, exposed to 24/7 news cycles that remind them of the interconnectedness of the world know, almost intuitively that "continual growth in population and consumption could severely damage the ecosystems and social systems that support life on earth, and that a drive for limitless economic growth could eventually disrupt many local, regional and global systems." [7] Parkinson confirms this sense of global awareness by adding that "advances in telecommunications and other enabling technologies, . . . political events which have opened up many formerly closed societies, the adoption of economic policies which have promoted free trade and the expansion of multi-national corporations" [8] In short, many of our graduates today are have become broadly based systems thinkers. And an additional driver of this change in engineering culture, the thing that makes all of this possible may well be the concept of "sustainability."

Sustainability, simply put in the promotional material for the 2009 National Sustainability Design Expo, is defined thusly:

> In a world where water and energy resources are finite and our consumption of goods is increasing, we need more creative ways to integrate social, economic, and environmental goals. The task ahead is to design a sustainable future where the environment is protected, people are prosperous, and the quality of life improves through innovative science, technology, and policy [9]

The concept of sustainability shifts the problem from an amorphous idea that is out there in the world and not the immediate responsibility of an individual to an idea that is present, relevant and important to those of us who purport to solve problems., It implies something more than a technical fix, an immediate solution, or an analytical exercise. Sustainability requires us to perceive and think about the problem differently from our forefathers who likely believed that given time the world would heal itself or that our scientists and engineers would just find a way to solve an immediate problem. Sustainability requires us to examine our behavior as well as externalities like climate change or concrete jungles. Sustainability, the concept, has changed the world view of our students. Thinking in terms of a world that is healthy and clean, becomes a personal responsibility. Almost without thinking about it, students have internalized the idea that sustainability is part of their world and requires attention.

Students and innovative faculty in engineering programs are the agents of change in the engineering paradigm. They are champions of humanitarian engineering programs, participating in projects under the auspices of organizations like Engineers Without Borders, seeking volunteer opportunities in the Peace Corps, and looking for opportunities in companies that share their vision that engineers must leave the world a better place. For many, the concept of sustainability forms the underpinning of their passion to change the direction of engineering culture.

Colorado School of Mines students are similar to other engineering students insofar as they have the opportunity to explore global and local problems through the lenses of their engineering program and courses that open their eyes to the social, political and economic opportunities and constraints that can alter outcomes. By participating in the honors program students come to appreciate the importance of public affairs to engineering project design. Students in the humanitarian engineering program, environmental science and engineering program and design classes have opportunities to develop solutions within the context of local community needs, international development conundrums, or persistent poverty conditions. The problem may be introduced as a challenge to provide a way for the small farmers of Somali to store their onion crop so they can sell the product under more favorable conditions. Another group may work on providing clean water to a relocated village of Hondurans. A third group may simply sign up for a Habitat for Humanity home building project in South Africa or Mexico. As Cathy Skokan and David Munoz said, at this conference in 2007,

> The overall goal…is the creation of a new cadre of engineers sensitive to social contexts, committed and qualified to serve humanity by contributing to the solution of complex problems at regional, national, and international levels and locations around the world in need of "smart" technical assistance in meeting the basic needs of humanity. [10]

The Lafayette College Sustainable Development Guide [11] lists a number of important considerations that are indicative of a paradigm shift in the culture of engineers:

- An ability to work within the existing systems of the project when determining appropriate solutions
- Community participation and ultimate ownership of the solution

- Empower the community to sustain the solution
- Use local resources if possible and in a way that conserves those resources
- Identify solutions that do not require a continuous external infusions of resources
- Think about long-term durability rather than quick fixes

The faculty has also been instrumental in this paradigm shift. Humanitarian engineering programs are thriving at numerous engineering universities: the University of Connecticut, Pennsylvania State, Dartmouth, Valparaiso, the University of South Florida among others. Internationally France can take credit for Engineers without Borders and today there are programs in Canada, Australia, Africa and throughout the Americas. Daniel Almagor in a 2005 interview said

> from November 2003 till now June 2005, just over a year and a half, we've got just under 1,500 members. About 50 percent of our membership are students who need to get more out of their engineering than what they feel they're getting. We have a lot of recent graduates, we say young engineers but really you know 25 to early 30s, people who, again are passionate and want to get involved. And then we're getting an increasingly larger number of experienced engineers getting on board. It started off with very few. I think we're grown quicker than I can handle, I'm definitely new at this and I don't know how to do it, but yeah we are growing and we're getting more and more engineers and non-engineers on board as well. We've got architects and anthropologists and social workers, economists, who are also passionate and see that we can make a difference here. [12]

The National Society of Professional Engineers supports the sustainability idea in its Code of Ethics. Michigan Tech talks about its first semester program that enables students "to define sustainability, determine the sustainability of their own lifestyles, and investigate the sustainability of technological advancements." This is followed by a second semester course that teaches students "to evaluate the economic, environmental and social aspects of their designs in order to produce sustainable solutions." [13] As importantly, corporations increasingly recognize the importance of community involvement and sustainability.

Newmont Mining representatives speak to my students in the McBride Honors Program. When preparing for our guests, students are almost unanimously opposed to Newmont, believing that it acts irresponsibly in the communities where it has mines, seeks only serving its stockholders with profits, and has little respect for the environment. After talking to Newmont personnel, who genuinely seem to care, and an examination of the literature, both pro and con, our students tend to change their minds and begin to think about ways they can work for big corporations and make a difference. Newmont's message is powerful:

> Sustainability can be summarized in four key principles: First, benefits of economic activity must be considered in relation to their respective social and environmental consequences; second, in using resources, we must consider the needs and expectations of future generations; third, government, business and other segments of civil society must act together to balance these needs; and fourth, corporate governance is a critical component of our ability to achieve success in meeting our business and sustainable development objectives. [14]

"Culture changes when new environmental stimuli challenge or conflict with existing perceptions and interpretations, requiring a search for new actions and practices and prompting results that modify cognitive schemata, or when new stimuli trigger old actions and practices that reflection fails to validate." [15] We have suggested that global awareness and almost constant chatter about the deterioration of the world's resources are powerful catalysts for a paradigm shift in engineering culture. Whether designing a flood management system or bringing clean water to a village of a few thousand, our engineering graduates are interested in taking positive steps to act responsibly within the global context. Our faculty are seeking projects that foster sustainable responses to human needs. They are using technology that is appropriate to the situation, consistent with societal values, and economically feasible. In short, their perspective has shifted from solve the problem with technology and know-how to solving problems in a way that is appropriate and sustainable.

Our graduates may take jobs with large, multi-national corporations but it is likely they will not support a top down approach to development. They understand that the long-term success of a project depends on an approach that recognizes social capital, are culturally appropriate and are supported by local participation. Their work must fit into an environmental and cultural context. They want to see benefits

for communities, writ large. The idea that a one size fits all technological approach to a problem appears to have given way to identify solutions that do not destroy non-renewables and marginalize people but also make financial sense.

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