A Summary of the Workshop on Integrating Appropriate-Sustainable Technology and Service-Learning in Engineering Education

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The University of Colorado at Boulder (CU-Boulder) hosted a workshop entitled, *Integrating Appropriate-Sustainable Technology and Service-Learning in Engineering Education* on September 27-29, 2004. This workshop was funded in part by the National Science Foundation (NSF) and the National Collegiate Inventors and Innovators Alliance (NCIIA). One objective of this workshop was to provide a forum for engineering educators and students as well as representatives from NGO's, governmental agencies and international consultants to share information and exchange ideas regarding appropriate technology program and course development and/or the integration of appropriate, sustainable technology concepts into existing programs and courses. A second objective of this workshop was to explore the challenges and benefits associated with incorporating service-learning into engineering courses.

Objective 1: To Provide a Forum to Share Information and Exchange Ideas
Sixty-three participants from 45 different organizations in eight countries attended the workshop that consisted of keynote lectures, presentations, breakout sessions, and plenary discussion periods. Facilitated discussion periods explored the strengths, weaknesses, opportunities and implications of incorporating appropriate technology, sustainability and service-learning into the engineering curriculum. Topics addressed in this workshop included: (i) the university perspective on incorporating service-learning, appropriate technology and sustainability in engineering education; (ii) presentations of the views of the various stakeholders involved in service-learning and appropriate technology; (iii) information regarding what is currently going on in engineering education as related to service-learning; and (iv) appropriate technology and sustainability and the implications of this new mindset on education, industry and society.

Thanks to an NSF-funded Department-Level Reform (NSF-DLR) one-year planning grant, a sub-group of participants met for several hours to help develop new Engineering for Developing Communities tracks within the Civil Engineering and the Environmental Engineering B.S. programs and incorporate Earth Systems Engineering and sustainability ideas throughout the curriculum within the Department of Civil, Environmental, and Architectural Engineering (CEAE) at the University of Colorado at Boulder. Once designed, the new curriculum will be the basis for an NSF-DLR three-year implementation grant proposal.

Speakers presented a variety of options to integrate appropriate/sustainable technology concepts into the engineering curriculum. Those options ranged from adding pre-developed modules (such as those presented by Karlson "Charlie" Hargroves of The Natural Edge Project[1]) into existing syllabi, to teaching interdisciplinary courses specifically focused on solutions for the

developing world (Amadei[2]). Several speakers addressed the point that people are, or should be, the paramount interest in this type of work and that technological solutions need to be specifically designed to help the end users. Barrett Hazeltine[3] suggested that students must be exposed not only to technology but also to its social implications and business aspect. He also remarked that the ultimate mission of the enterprise is to improve people's lives and that technology is not an end in itself.

Appropriate technology addresses the needs of a community in a sustainable manner. It is usually characterized as being small scale, energy efficient, environmentally sound, labor-intensive, and controlled by the local community. It must be simple enough to be maintained by the people using it. Furthermore, it must match the user and the need in complexity and scale and must be designed to foster self-reliance, cooperation and responsibility.[4] It should be noted that the field of appropriate technology is not usually addressed in engineering education and university research, as it is often perceived as "low tech" and unimportant. Studies by the World Bank and the United Nations have shown, however, that appropriate technology is critical to bringing more than three billion people out of poverty.

Sustainability requires using available resources in ways that meet current needs without imposing a burden upon or decreasing the ability for future generations to meet their own needs. As defined by the World Commission on Environment and Development, "sustainable development" is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[5]

The system that industrialized nations have developed is not sustainable. In fact, what many deem as "progress" has come at the expense of people's health and the well-being of planet Earth. If the human race is to survive into the next millennium, there needs to be drastic changes in the way people think and act. It was argued that one of the first things that educational institutions need to do is to evaluate their own "ecological footprint" and determine if their own organizations are ecologically sustainable. As remarked by Anthony Cortese[6], we have "a crisis *of* education, not one *in* education".

Stephen Martin, an independent consultant on sustainability and visiting professor at the Open University in the UK, proposes that educational institutions need to "practice what they preach" and focus on decreasing their own ecological damage while at the same time teaching students in all academic programs about sustainability. Dr. Martin cited research showing that travel to and from campus is one of the largest impacts that a university has on the ecosystem, and that distance learning can significantly decrease the CO_2 emissions produced by universities.[7]

Distance learning was the solution implemented at the University of Borås in Sweden to allow students from several countries to interact in real-time. Dr. Claes Helgesson[8] described how the two year International Master's Program in Implementation of Sustainable Technology runs in parallel at the University of Borås (Sweden), the University of Redding (UK) and the University of Yogyakarta (Indonesia), with each university taking primary responsibility of specific parts of the curriculum for students at all three locations. The limit to this distance learning plan comes when the student chooses a specialization. At that time, students must transfer/travel to the university where that specialization is offered.

Workshop attendees were excited to have the opportunity to share their plans, as well as their successes and challenges. After the workshop, a website was set up for workshop participants to continue sharing information and resources (http://quickplace.udayton.edu/QuickPlace/slate). That website allows members to upload resources including syllabi and documents relating to appropriate/sustainable technology and/or service learning. The website also includes links to relevant organizations including Engineers Without Borders-USA (EWB-USA), the Engineering Projects in Community Service (EPICS) and Engineers in Technical Humanitarian Opportunities of Service-Learning (ETHOS) programs, Campus Compact, and others. The group was also enthusiastic about the possibility of meeting again at other conferences including the Engineering Sustainability Conference in Pittsburgh in April 2005, and the American Society of Engineering Educators conference in Portland in June 2005. Finally, the group supports the idea of having another workshop next year with the same participants, specifically to discuss recent accomplishments and next steps.

Objective 2: Exploring the Challenges and Benefits Associated With Incorporating Service-Learning Into Engineering Courses

According to Dean Robert H. Davis, of the CU-Boulder College of Engineering and Applied Science, service-learning (or in more general terms, experiential education) is important because it helps students to nurture a lifelong desire to consider the social and economic importance of their work. It also offers personal gratification in helping others. The exact details of how service-learning and experiential education are integrated into a student's college career are not as important as the fact that the students gain this experience. In fact, during the three-day workshop, it became clear that there are a wide variety of ways to incorporate experiential learning into the lives of engineering, and non-engineering, students. The bottom line is to create well-rounded individuals who recognize the global significance of their work. It is also important that service-learning be integrated as early as possible into undergraduate education and education in general.

Service-learning methods presented during this workshop varied from work performed by students on their one day off per week at Muffakham Jah College of Engineering and Technology in Hyderabad, India[9], to students completing required interdisciplinary research projects relating technology and science to society or human needs at Worcester Polytechnic Institute[10]. At some institutions, students completed service-learning projects in faraway countries, while others tackled projects in local communities.

Workshop attendees reiterated the importance of conveying the message to students that "developing communities" are not just "over there." Students need to realize that a large number of people struggle to meet their basic needs even in the largest cities in the United States.

In fact, according to Anthony Cortese[11], President and Co-Founder of Second Nature, 90% of the U.S. economy focuses on meeting people's wants, not their needs. At the same time, the world is dealing with the following vital issues:

- Two-thirds of the people will have a water shortage in the next 50 years
- Global warming – effects occurring at faster rate than estimated
- Species extinction – 20 % (death of birth)
- Population/consumption momentum

- Gap between rich and poor getting worse
- Most impacts are invisible, unintended, hard to understand, and difficult to accept

Steve Werner[12], Executive Director of Water for People reiterated the inequities on our planet with respect to water. For instance, women in developing countries spend on the average three months per year in hauling water. Waterborne diseases are implicated in 80% of sickness and diseases worldwide.

Over and over again, speakers described how small, inexpensive projects can have major social impacts on developing communities. For instance, in 2000, at the request of a representative of the Belize Ministry of Agriculture, Dr. Bernard Amadei[2] and a group of CU-Boulder students traveled to San Pablo, Belize to examine the possibility of designing and installing a water delivery system. Since the village had no electricity, running water, or sanitation, and because most villagers worked at a nearby banana plantation, the responsibility for carrying drinking and irrigation water from a nearby river to the village fell to the village children. In a few weeks, with about $14,000, this team accomplished their goals. Now those children can go to school and have a greater opportunity to meet their full potential.

In Nepal, each 75 watt solar photovoltaic generator installed by Alexander Zahnd[13] and his colleagues from Kathmandu University produced enough energy to install up to three White Light Emitting Diode (WLED) fixtures in 20 homes. Using WLEDs for lighting, and efficient smokeless metal stoves for cooking, improved the air quality inside homes and decreased wood consumption dramatically compared with the tradition of using an open pit fire for both lighting and cooking. Again, the social impact was immediate and profound. Having light in their homes that did not require daily trips to gather 30-50 kgs of firewood allowed these villagers to spend more of their time reading and studying. It also significantly decreased the speed at which natural wood resources were being depleted.

Here in the US, the EPICS program focuses mainly on local or regional service learning opportunities, although they are making plans to expand to national and international projects. Bill Oakes[14], EPICS program Co-Director and Associate Professor of Engineering Education at Purdue University, stressed how local service-learning projects allow students to fully-integrate into their local community. Plus, local projects allow increased participation without a significant increase in expense which is a critical issue if colleges and universities want to offer service-learning opportunities to the majority of their students. Dr. Oakes reiterated that service-learning can be implemented in a variety of ways: as a co-curricular activity, as an integrated theme within a course, as a stand-alone course, or in conjunction with a program such as EPICS, ETHOS, or EWB-USA.

It is clear that service-learning projects can easily be incorporated in senior design studies and capstone courses. For instance at the University of Massachusetts Lowell campus, 80-100% of the students in electrical engineering work on assistive technology projects for handicapped as part of their senior design projects[15]. Other examples were presented by David Vader[16] from Messiah College and Amy Smith[17] from MIT.

Several speakers discussed the various opportunities available to students interested in appropriate technology and service-learning in the US and abroad. Bernard Amadei[2] talked about the many international opportunities available through Engineers Without Borders – USA. Rebecca Hovey[18] from the School of International Training (SIT) based in Brattleboro, Vermont mentioned that SIT offers international undergraduate programs to over 1,600 students per year and works with 200 partner schools in the US. Additional opportunities were presented by Karen de Bartolomé[19] from the Institute of International Education and Julie Zimmerman[20] from EPA.

Service learning implies a need to create new and innovative partnerships between several stakeholders that have not traditionally worked together in the past. They can be between schools, schools and communities, and involve NGOs, foundations, corporations, etc. A good example was presented by Tom Van Dam[21] from Michigan Tech where engineering education is done in partnership with the Peace Corps.

The benefits from service-learning were discussed and include:

- Increased student recruitment, retention and involvement, especially among women and underrepresented minorities;
- Increased student's understanding of technology and the interaction between technical and non-technical issues;
- Opportunities for students to work in a real world environment, with real constraints and unexpected challenges;
- Having a legitimate opportunity to fail, and then having the chance to step back, evaluate what went wrong, and try again. This opportunity to learn through failure could help students become better professionals — when failure is not considered an acceptable option.

Challenges mentioned during the workshop included

- Funding and liability issues;
- ABET accreditation and requirements;
- The time involved in incorporating service learning into existing courses, in developing new courses, and in managing team projects;
- The need to convince people (administrators, faculty, and funding agents) that service-learning experiences can be as rigorous as (or more rigorous than) traditional teaching methods. Anthony Cortese[6] argued that the best way to describe what we want to do is "experiential co-learning" rather than service-learning. "Experiential" describes an active method of inquiry and "co-learning" recognizes the fact that everyone involved gains knowledge from the experience. The "teachers" become facilitators of a learning process rather than being seen as the experts who must impart specific knowledge to their students.
- The need for a paradigm shift to change the image of engineers and engineering. Students should be encouraged to study engineering because engineers help people, make the world a better place, solve important problems, and design solutions to some of humanity's most basic problems (not just analyze those problems). Engineers are a key to sustainable development. Young people need to understand

that engineering is a "profession in which knowledge of the mathematical and natural sciences…is applied with judgment to utilize, economically, the materials and forces of nature for the benefit of mankind."[22] Engineering is more than solving technical problems!

Summary

How can the workshop participants and other interested faculty, students and industrial, governmental and nonprofit representatives encourage the teaching of sustainable and appropriate technology throughout all majors, within engineering and beyond? Educators must encourage people, especially current and future students, to realize that an individual's own well-being is integrally dependent on the overall well-being of the community. It's time to realize that academic exercises cannot solve the world's problems. How can the non-believers be convinced that service-learning is a valuable and rigorous learning tool?

Educators will have to make the case on the grounds of pedagogy by showing that experiential learning improves students' learning. According to Martin Bickman[23], Professor of English and Director of Service Learning at CU-Boulder, "Knowledge isn't really knowledge until it is operational." This means that students can't really know something just by reading it in a textbook. They need the opportunity to perform the task in order to truly learn. Dr. Bickman also stresses that reflection is a critical component to bring the experience back into the abstract learning process. Also, partnerships are critical to long-term success of service-learning projects in developing communities. Communities need to have a sense of project ownership; otherwise the projects are doomed to fail. Setting expectations early will keep people from being disappointed when modest results are achieved. Once a community's basic needs are met, then they can begin to consider ways to improve their economic situation.

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