

**AC 2007-1017: COMMUNITY-BASED LEARNING: CREATING
INTERNATIONAL SUSTAINABLE DEVELOPMENT ENGINEERS**

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Community-Based Learning: Creating International Sustainable Development Engineers

1. Introduction

There has been increased recognition that the world faces serious challenges in terms of long-term economic growth, societal prosperity, and environmental protection. In particular, health problems resulting from environmental risks and a lack of economic resources in the developing world pose daunting challenges to the global scientific and engineering communities. Addressing these challenges through international research experiences integrated with sustainability and appropriate technology principles represents a significant and critical contribution to a more sustainable future. This has been called for both within and outside engineering education, starting at the undergraduate level.

Initiated in Fall 2006 with the help of a NSF grant, this program engages engineering student teams in community-based learning (CBL) outside La Paz, Bolivia. CBL is defined as learning via working with and in a community in need of engineering (or other) services. In this way, the student's research efforts in this program will be socially relevant and useful at the community level, and will foster knowledge transfer from the developing world to the industrialized world. It will also increase students' understanding of appropriate technology, engineering equality, and social justice. This paper will present the program design, student participation, and lessons learned to date.

2. Program Design

The four main goals of this CBL experience are: (1) to provide engineering students experience working on diverse teams, (2) to produce engineers with a better sense of the societal and global interconnections of engineering works, (3) to enhance the real-world problem-solving and research capabilities of students, and (4) to work with developing communities on appropriate sustainable solutions to environmental problems.

Three student teams, each composed of two American engineering students (one undergraduate, and one mentoring Ph.D. student) and two Bolivian engineering students, partner with a Bolivian NGO and Bolivian community members to assess, plan, design, execute, re-assess, and communicate research related to a sustainable development project for the community. The American undergraduate engineering students are selected from a recently started Certificate in International Sustainable Development Engineering program, the doctoral students from a Graduate Certificate in Sustainability program. The Bolivian students will come from the engineering program at Universidad Tecnológica Boliviana in La Paz.

The program commenced with a campus-wide solicitation of participation. While this program is designed to draw students from two existing sustainable development programs, the undergraduate program was only recently approved by the University;

hence for this first year, all undergraduates could apply. Six students were notified in mid-December, and had until mid-January to accept the offer.

The American student teams and one faculty member will reside in Bolivia for all of June 2007. Before then, teams and projects will be developed. To aid in the first, monthly meetings will be used to build team camaraderie, critical for getting through the occasionally stressful trials of work in developing communities. Once the teams are decided in early February, the American and Bolivian students will begin to share discussions on group readings to better prepare for sustainable development research. Readings will be assigned monthly and discussion of the readings will serve as a major component of the monthly meetings. The American students will also be encouraged to attend relative international development seminars on campus prior to departure.

In March, the Non-Governmental Organization (NGO) partner, ACDI/VOCA Bolivia, presented potential projects to the student teams, all involving recent water and wastewater facilities in the partner community. ACDI/VOCA works with the partner community (Palos Blancos, Bolivia) on development projects and will serve as the intermediary between American and Bolivian university students and the community prior to the team's arrival in Bolivia. The Mosevenes Indians are the most important population in the area, besides the Aymara and Quechua colonizers. The exact nature of the project will be defined by the team and community members. Table 1 illustrates how development projects motivated previous research projects (designed and executed by students in other programs at our university) and reflects some of the types of research projects that could emerge in this program. Using the community interests communicated by the NGO, the student teams will begin to design as much of their research plan as possible in April and May. June will be used for refining the plans with community members and executing most data gathering. July through September, the teams will analyze and interpret the data collected, and document findings (in English and Spanish, both technically and for the lay person). The program culminates in October with public presentations during our university's annual International Sustainable Development Engineering Colloquium. Summary documentation will then be delivered to all partners. Figure 1 illustrates the general steps in this program. This program flow will provide research experience for the undergraduates and invaluable mentoring experience for the doctoral students.

3. Student Participation

Table 2 shows the student demographics for the inaugural offering in summer 2007. The applicant pool consisted of six majors. Nearly two-thirds of all applicants and program participants are women. This proportion is slightly higher than the percentage of female students in our university's numerous international sustainable engineering programs (an average of about 50% women for those programs). Half of the student participants are active in other international sustainable engineering programs or organizations on campus. All of the students have some Spanish language competency, on average two years of classroom training. All of the students who applied envision doing engineering work in developing communities as their professional pursuit. Due to the breadth of

majors, bi-nationality of teams, and partnerships with NGO and community members, the student participants will be ensured work on diverse teams.

4. Lessons Learned

At the time of writing, there are a few critical lessons to share, particularly on program design and execution (but at time of presentation, the in-country portion will have just concluded, so additional lessons will be available on student outcomes). This program builds on many years of successful international sustainable engineering programs at the American university; as such, many issues have been dealt with before and such issues should be minor for this program. Issues always arise in-country, and program weaknesses and improvements will be evident after the first program year (of three) concludes in October. However a few lessons to date include:

- Many students are attracted to this type of program, notably women. Two-thirds of the program participants are women. The combination of international setting, service, and community-based learning are immensely appealing. The students selected for the program are uniformly ecstatic about the opportunity. Traditionally academic programs should take note, should they hope to match the demographics and enthusiasm of this program.
- This type of engineering work is widely appealing. Among the six students, there are six different majors represented. The emotional connection to engineering in developing communities clearly resonates with many students (and clearly does not for others). Yet, it is the emergence of such emotion that makes the learning deep. These programs provide great lessons on how to fix most typical university curricula.
- An assessment protocol has been developed that extends beyond the typical cognitive domain that engineering programs focus on. The assessment protocol for this program focuses on cognitive, affective, and physical domains and is scaleable. The pre-assessment has already produced unexpected insights.
- The in-country portion could be better placed, probably in May. This year, due to the short notice between grant notification and program startup, the in-country phase was a compromise between the universities and NGO. However, for the American university, May would be a better month, as it would allow students participants to enroll in Track B summer classes or pursue a June-August summer internship. July would result in similar summer fragmentation as June. August is not possible for the Bolivian students as it is the start of their school year.
- It is too early to conclude, but the challenges of fully integrating the Bolivian students into the team are not fully evident. Whether the internet (discussion boards) and conference calls will be adequate international collaborative tools is unknown. It is also unclear of Bolivian student motivation will match their American counterparts. These challenges, if they exist, will be excellent real-world experience for the American students. Real team diversity extends to motivation, attitude and interest. The first week

of in-country residence will focus on team interaction to facilitate any solutions to these challenges.

- Like most successful international programs, this one requires considerable faculty investment, in this case, a one-month residency in Bolivia. Current university load and reward systems are inadequate to fully consider the effort. Faculty who engage in programs such as the one highlighted herein will need to sacrifice traditional work demands. Additionally, there is not an easy way to account for the emotional and physical demands of programs in developing community settings; faculty need to be aware of their own limitations, yet be available for students in ways that tend not to be needed on campus.

Table 1. Research projects representative of the types of projects planned for this program

Community Development Project	Resulting Research Project
Water supply systems (wells, pumps, rainwater harvesting), solid waste management, and sanitation systems (wash areas, soak pits) in Mali	Determined how socio-economic, organizational, and political factors which contribute to sanitation development, differ in rural, urban, and peri-urban areas. Developed decision support tools to manage projects in these areas.
Ventilated improved pit latrines and spring boxes in Cameroon	Conducted a year-long health survey in two villages specifically to assess the link between newly constructed water and sanitation projects and community public health.
Promoted new stove models in Panama	Measured indoor air quality in a dozen homes to assess public health consequences and possible engineered intervention methods.
On-site wastewater treatment systems (wetlands, evapotranspiration ponds, lagoons) in urban and rural areas of Jamaica	Used detailed water quality analyses and hydraulic/cost information; evaluated performance of subsurface wetlands used to treat wastewater in rural communities of the developing communities.
Watershed management, double pit compost latrines, water supply, and solid waste management in Vanuatu	Researched stakeholder involvement in multiple land use planning activities within watersheds located in the developing world.

Table 2. American student participant demographics

Students	Majors	% Female
Undergraduates	Environmental Engineering Civil Engineering Electrical Engineering	66%
Doctoral	Environmental Engineering Mechanical Engineering Environmental Policy	66%

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TIFF (LZW) decompressor
are needed to see this picture.

Figure 1. Program flow schematic