Humanitarian Engineering Program – Challenges in the Execution of Remote Projects

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Abstract - **The overall goal of the Humanitarian Engineering Program at Colorado School of Mines (CSM) is the recruitment and education of a new cadre of engineers, sensitive to social context, committed and qualified to serve humanity by positively contributing to the solution of the complex problems of the underserved at regional, national, and international locations around the world in need of "smart" technical assistance. We are achieving this goal through the development of a comprehensive humanitarian engineering curriculum wherein engineering students learn how to incorporate technical knowledge and cultural awareness toward finding appropriate solutions to real-world problems faced by the less (materially) advantaged. As part of the Humanitarian Engineering program, many of our students travel to areas in need, either within the United States or internationally. There are numerous challenges that face the school, faculty, and students as these trips are planned and executed. These challenges span a range from cultural sensitivity with background knowledge to funding of travel costs and health and safety issues. In educating engineers in the 21st century, greater emphasis is placed on achieving an improved understanding of the world in which graduates will work, in addition to building solid technical skills.**

Index Terms – Humanitarian Engineering, Service Learning, Travel Challenges

THE HEWLETT-SPONSORED MINOR IN HUMANITARIAN ENGINEERING

In 2003, the William and Flora Hewlett Foundation initiated the Engineering Schools of the West Initiative (ESWI), and awarded ten million dollars in grants to nine engineering institutions located in the western United States [1]. The nine schools are Boise State University, Colorado School of Mines (CSM), Montana State University, New Mexico State University, Northern Arizona University, Oregon State University, University of Nevada, Reno, University of Utah, and the University of Wyoming. The purpose of ESWI is to support efforts that seek to improve the recruitment and retention of engineering students and the learning that occurs in the undergraduate engineering classroom. The Humanitarian Engineering program at the CSM is funded through ESWI.

The overall goal of the Humanitarian Engineering program at CSM is the creation of 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. We are achieving this goal through the development of a comprehensive humanitarian engineering curriculum that provides an environment in which engineering students and faculty can learn how to best bring technical knowledge and skill to bear on the real-world problems of the less materially advantaged in order to promote development of the common good. This curriculum leads interested students toward a minor in Humanitarian Engineering.

Four specific goals of the Humanitarian Engineering program are defined in the original proposal: create a culture of acceptance and value of community and international service activities at CSM; increase the number of CSM engineering graduates that enter occupations that have a community or international service emphasis; increase the recruitment of women and minority students to the engineering program at CSM; and increase the number of engineering students that enter internships in community or international service.

Incorporation and implementation of humanitarian projects into Senior Design [2] is one component of the new minor program in Humanitarian Engineering. This is the "capstone" experience where the student can apply the technical and non-technical tools to achieve a reasonable solution to a pressing human need. Interdisciplinary teams of students are faced with real-world problems and work on a solution for two academic semesters. Travel occurs either early in a project or at the end of a project. Early travel gives the team a picture of the environment for which they must develop a solution to a problem. Travel at the end of the two-semester sequence is for the purpose of implementing the project design. Teams traveling to foreign locations travel once while those traveling within the state might have the opportunity to travel at the beginning and at the end of a project. Economic constraints limit the more expensive travel opportunities. At this point, travel expenses including transportation, housing, and food are covered by the university through the Hewlett grant and other gifts. We wish to continue this policy so that we can give this important opportunity to all students, not just those with better economic means. All trips include a faculty advisor to accompany the student teams.

LITERATURE REVIEW

The concept of service learning as an important educational experience for students is summarized by Cooper [3]. He lists the goals of service learning which include:

- To enhance student learning by joining theory with experience and thought with action.
- To fill unmet needs in the community through direct service which is meaningful and necessary.
- To enable students to help others, give of themselves, and enter into caring relationships with others.
- To assist students to see the relevance of the academic subject to the real world.
- To give students the opportunity to do important and necessary work.
- To increase the civic and citizenship skills of students.
- To expose students to societal inadequacies and injustices and empower students to remedy them.
- To develop a richer context for student learning.
- To provide cross-cultural experiences for students.

The Semester at Sea program [4] stresses the importance of travel as part of education as well. They summarize this importance:

- Develop an awareness of some of the important elements of interdependence necessary for coexistence in the world today and tomorrow.
- Build insight and background for interpreting international problems and conflicts.
- Clarify awareness of your own culture through contrast with others.
- Grow through the challenge of living and learning in a closely integrated environment.
- Interact with other cultures providing a historically relevant perspective of both developed and emerging nations of the world.

More specifically, when researching the usefulness of service learning in engineering, Paquin [5] states: "The field of engineering, with its foundation of problem solving and co-op elements, is in a unique position to revisit its civic mission. Others [6,7] strongly support the concept of service learning for engineering students and its importance in meeting ABET expectations. ABET requires that students be able to: "demonstrate that their students attain the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" [8].

SENIOR DESIGN PROJECTS THAT INVOLVE TRAVEL

Since 2003, twenty humanitarian senior design projects have involved travel (see Table I). Seven of these required travel within the State of Colorado with distances ranging from 75 to 275 miles from campus. Students traveled within the United States but outside of Colorado for three projects. The remaining ten projects involved travel outside of the United States to countries with developing economies. There are challenges with each type of travel.

TABLE I.
HUMANITARIAN SENIOR DESIGN PROJECTS ASSOCIATED WITH TRAVEL

TERM	PROJECT	SITE	# STUDENTS
Spring, 2003	Water Infrastructure	Lemraiveg, Mauritania	5
	Cedaredge Middle School Engineering Curriculum	Delta School District, Colorado	4
	Solar-powered electrification of church, community center, and women's health clinic	San Pablo, Belize	5
	Onion Storage Facility	Rao, Senegal	4
	Biomass Usage	San Luis Valley, Colorado	5
Fall, 2004	Centennial Elementary School Curriculum	Harrison School District, Colorado	5
	Drip Irrigation	Rao, Senegal	5
	Installation of a pump and piping	San Pablo, Belize	6
	Water and waste-water treatment	Colinas de Suiza, Honduras	7
Spring, 2005	Salvation Army - Bridge	High Peaks Camp, Colorado	4
	Village Lighting	Amazon Region, Ecuador	5
Fall, 2005	RV Park for Tribal Community	Gulkana, Alaska	8
	Gifted and Talented Engineering Curriculum for elementary school	Colorado Springs, Colorado	6
	Water and waste-water treatment II	Colinas de Suiza,Honduras	6
	Cedaredge Middle School Learning Wall	Cedaredge, Colorado	5
Spring, 2006	Oglala Souix Housing	South Dakota	4
Fall, 2006	Delta Co. Middle Schools Learning Wall	Delta, Colorado	8
	RV Park for Tribal Community II	Gulkana, Alaska	7
	Water and waste-water treatment III	Colinas de Suiza,Honduras	6
	Water Pump for multiple fields	Ghana	6

CHALLENGES AND APPROACHES

Challenges occur with a Humanitarian Program that involves travel within the state, the country, or outside of the country. These challenges include identification of an appropriate project and location, the funding of the project and travel, logistics, safety issues, and building of local support, rapport and trust.

Identifying a Project

An early challenge is finding an appropriate project. Often there are constraints imposed by sponsoring groups. Our

approach to avoid excessive problems in this area has been to remain religiously and politically neutral and to emphasize human-sensitive engineering as a problem solving tool. We try to use local sources and work on community-suggested problems. It is important that we do not impose our ideas on a community, but that we work together toward a solution of an engineering problem. One example is the design of an RV park for an Athabascan community in Alaska. The community has a high unemployment rate and would like to offer job opportunities to the locals. They are situated near the St. Elias National Park and felt that a property that they owned could become an RV park. Our students have worked on that park design in conjunction with the local community (see Figure 1).

Figure 1. RV park site in Alaska.

Funding a Project

All travel has associated costs for students and for accompanying faculty. The Hewlett Foundation has supplied funding for travel in humanitarian project but has only a five-year life span. We have actively sought funding from other sources and have received donations from alumni as well as Mondialogo (UNESCO and Daimler-Chrysler), Shell Oil, and personal contributions from alumni with interest in the projects. We also insist that those who are receiving the benefits of a humanitarian project help with on-site expenses and manual labor. This is necessary because it gives the community ownership of the project. We have received contributions from local communities in the areas of food, housing, and/or local transportation.

Logistics

There are many challenges in the area of logistics when implementing a senior design project in an off-campus location. These challenges are magnified when working outside of the culture and country in which the students are comfortable. Our humanitarian engineering students are required to take course offerings from a specified list of Liberal Arts and International Studies (LAIS). Some of these are general courses in ethics or more focused on the specific problems associated with humanitarian work. Some are an area studies courses associated with the International Political Economy from LAIS In addition students will independently research the country or area they will be visiting. If traveling outside of the United States, once in the country, each traveling team must register with the US Embassy and should maintain contact with the Peace Corps or NGO sponsoring their visit.

In bringing supplies into a country, customs and import regulations must be observed. These regulations and requirements must be thoroughly understood prior to shipping materials. Communication with local contacts can help in this area, as well. However, local rules may change suddenly. One example occurred with the drip irrigation project in Senegal (see Figure 2). We had purchased a large amount of irrigation piping at a reduced cost in the United States. We researched the import regulations for Senegal and were told that humanitarian goods would not be charged import duty. We made arrangements for letters from officials to verify the humanitarian status of our project both in the United States and in Senegal. However, when we arrived in Senegal, our shipment would not be released until we paid a customs fee of many thousand dollars. We were told that misuse of the humanitarian policy had caused the customs agents to reconsider and we were not granted a customs waiver. The lesson for the traveling team was that in dealing in unfamiliar circumstances, flexibility is a necessity. We need to be prepared for a moving target and have contingency back-up funds.

Figure 2. Drip Irrigation System in Senegal

In most cases, it is best to use local supplies. This avoids the problems of customs and provides capacity building in country. However, all materials may not be available in remote locations. Research will help to solve this problem. But at times, the students must adjust their design based upon the materials that are available. This type of experience is an excellent one for students as they develop their design capabilities. It is also best for local residents to purchase the supplies. The local resident has the ability to negotiate the best price for goods.

In design of project, students should be aware of local customs. They should check the use of local materials and traditions. This process can begin on campus, but travel to the location is the most valuable educational experience.

Health and Safety

Another set of challenges can be classified as health and safety issues. Prior to travel, each team member must attend a travel medicine clinic. Appropriate health practices, medications and vaccinations are discussed. Basic preventative measures such as drinking bottled water, not eating raw fruits and vegetables, and avoiding unpasteurized dairy products are discussed. The Center for Disease Control [9] has excellent resources for information on this topic.

Injuries can occur whether traveling to another country or in the same state. Heat exhaustion or heatstroke, sunburn, and insect bites might also be encountered. In order to deal with minor problems, the accompanying faculty member is required to complete a standard Red Cross First Aid Class. The travelers should determine the location of the nearest hospital upon arrival.

Both students and faculty should be aware of local laws and penalties. Our program has a firm no-tolerance policy with respect to drugs and this policy is clearly articulated to the students.

Finally, communication is important. Satellite phones are available for rental and are recommended for travel. Also, regular e-mail communication with campus is recommended.

Research into safety and stability of governments must be researched prior to visits. The US State Department is the best resource for up-to-date information [10]. In our first overseas project in Mauritania (see Figure 3), the students were caught in a coup. There were warnings that this might occur but the students chose to travel. This was our first group and no faculty accompanied the team. We now regularly check the US State Department recommendations for travel and have decided to forgo travel when situations seem problematic. A faculty member also travels with each student team.

Figure 3. Water Project at Lemraiveg, Adrar Region, Mauritania

Building Local Trust and Rapport

One of the challenges is the problem of corruption at local or national levels. This challenge can occur anywhere and is especially problematic when carrying technical equipment typically associated with humanitarian Engineering work. Traveling teams should develop an awareness of this as a possible problem. Coursework can lay a foundation for awareness, but flexibility in facing this challenge is important.

Another challenge might be termed “job displacement”. At times engineering solutions to a problem can create a reduction of employment. For example, in the Honduras water project, students have designed a water distribution system. At this time, a truck brings water to the community (see Figure 4). The need for truck driver and water-supply company will be eliminated. In building local trust for a project, the traveling team must interact with the local residents to understand the possibility of economic impact. Their design should include both an engineering as well as an economic and social/cultural analysis.

Figure 4. Truck delivering water to homes in Colinas de Suiza, Honduras

Therefore, traveling teams must develop a social, political and cultural sensitivity. Journey to a remote location is only one step in this process. Coursework can help lay a foundation, but this must be augmented with awareness during travel. The traveling team must take time to meet with local leaders to further understand culture. In all cases, treatment of others with respect is key.

Students design engineering solutions to problems, but the local population must have ultimate ownership of any project. The community should be involved in the project through financial contributions, often food and/or housing. Traveling teams should accept the hospitality of the local host. As well, local labor should be used to implement the final product to help build capacity.

CONCLUSIONS AND SUSTAINABILITY OF THE PROGRAM

While course work at the university can help prepare students for many technical and non-technical issues that can arise while undertaking an engineering project in a remote location, it cannot take the place of the experience at the site. Although we have only anecdotal feedback at this time, it does appear that student gain an appreciation of cultural differences. In the next year we will design and implement a formal assessment tool to make a quantitative measure of this gain.

Continuous assessment of this program shows that many of the goals have been met. The first goal, (create a culture of acceptance and value of community and international service activities at CSM) has been assessed in part through attitudinal studies [11]. The baseline data showed a greater acceptance by faculty than students at the beginning of the program. Four years into the program, the students now have an increased awareness of humanitarian engineering. The second goal (increase the number of CSM engineering graduates that enter occupations that have a community or international service emphasis) is difficult to evaluate this early in a program. However, anecdotal evidence shows an increase in students' desire to enter community-service oriented professions. Presently, we have two students participating in a graduate program that involves Peace Corps assignments, another student on assignment in Ghana working for the Peace Corps. About ten students have entered or plan to enter the field of public school teaching (see Figure 5). Travel off campus to work on projects, either within the state, US, or internationally has played a role in these decisions. One electrical engineering senior commented that prior to working on his humanitarian senior design project, that he had planned to continue working for a firm that had employed him as a summer intern. The pay for this position was quite good. Now, he has reconsidered and has taken a position with a bio-fuels company because he wants to make a difference, even though the salary in this position was much less than the traditional job. As more students graduate with a minor in humanitarian engineer, a better assessment of this goal will result. The third goal, to increase the recruitment of women and minority students to the engineering program at CSM, has been met [12]. The percentage of women requesting humanitarian projects as well as those registered for the Minor Program is significantly greater than the percentage of women at the university, in some cases twice that percentage. The final goal, to increase the number of engineering students that enter internships in community or international service, is a challenge for us. We have increased the number of senior design projects with humanitarian themes, but not internships. We will continue to work on this challenge and hope to reach this goal in the future.

Figure 5. Engineering taken to the middle school classroom in Colorado Springs.

Therefore continuation of the program has offered the final challenge. By establishing a Minor Program in Humanitarian Engineering, the university has shown a commitment to the concept. We need to continue to publicize the program and develop even more acceptance by the total faculty. We have made it known that Humanitarian Engineering is solid engineering with a humanitarian application. We continue to coordinate the program between the technical and liberal arts parties on campus. This is a separate challenge that is discussed in companion paper at this conference [13].

Maintaining a steady stream of high-quality projects will help to sustain the program. Once a project has been successful in a community, we continue to stay in contact and look for further project opportunities. We also teach the local residents how to operate and maintain completed projects. This includes both on-site instruction as well as written and pictorial instruction manuals.

Financial considerations must be considered for sustainability of this type of program. We continue to write grant proposals as well as identify and contact potential donors for an endowment. The faculty involved with this program feel passionate about the educational experience that the students receive.

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REFERENCES

[1] http://www.hewlett.org/Programs/Education/Opportunity/News/eswiNewsRelease.htm, accessed 04/07

[2] Skokan, C. K., Munoz, D., and Gosink, J., "Humanitarian Projects in Interdisciplinary Senior Design, ICEE, Gliwice, Poland, 2005.

[3] Cooper, M. "The Big Dummy's Guide to Service-Learning: 27 Simple Answers to Good Questions on Faculty, Programmatic, Student, Administrative, and Non-Profit Issues, http://www.fiu.edu/%7Etime4chg/Library/bigdummy.html, 1997

[4] Semester at Sea, www.semesteratsea.com, accessed 4/07

[5] Paquin, J. L., "How Service-Learning Can Enhance the Pedagogy and Culture of Engineering Programs at Institutions of Higher Education: A Review of Literature", U. Mass Amherst Dissertation, 2006.

[6] Tsang, E, "Projects that Matter: Concepts and Models for Service Learning in Engineering", Washington, D. C., American Association for Higher Education, 2000.

[7] EPICS National, "National Program", http://epicsnational.ecn.purdue.edu/public/program/national_program.php, accessed 4/07.

[8] ABET, "Criteria for Accrediting Engineering Programs", The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology., 2005

[9] Center for Disease Control Travelers Health, http://www.cdc.gov/travel, accessed 4/07.

[10] United States Department of State, "Travel Warnings and Consular Information Sheets", http://travel.state.gov/travel/cis_pa_tw/cis_pa_tw_1168.html, accessed 4/07

[11] Bauer, E., Moskal, B., Gosink, J., Lucena, J., Munoz, D., "Understanding Student and Faculty Attitudes with Respect to Service Learning: Lessons from the Humanitarian Engineering Project", ASEE Annual Meeting, June 2005, Portland, Oregon.

[12] Skokan, C. K, and Gosink, J, "Gender Participation in Humanitarian versus Traditional Multidisciplinary Senior Design Projects", ASEE Conference, Portland, OR, 2005.

[13] Munoz, D. R., and Skokan, C. "Humanitarian Engineering Program – Conceptual Challenges", ICEE, Portugal, 2007.