121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #9960

Building Effective Partnership Networks when Working Internationally

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In order to engage communities around the world, engineering educators must build international networks with relevant community organizations. Many factors can compound building effective networks. Organizations have different philosophies about how engineers should undertake community engagement. These philosophies include convictions that engineers should develop low-cost products suitable for markets in marginalized communities, engineers should devise clever solutions to help people living in poverty meet basic needs, engineers must effectively respond to sociocultural considerations when proposing solutions, and engineers should work to empower local artisans who have already begun seeking solutions to pressing problems.[1] Additionally, university programs have to overcome many geographic and relational barriers in order to have effective community access. This paper will discuss different strategies for building effective partnership networks when working internationally.

I will trace the evolution of partnership networks at globally engaged engineering programs at four universities using discourse analysis.[2] I reviewed all publicly available documentation that detailed the development of partnerships that sprung from assorted signature projects to determine how discourse models influenced building partnership networks. I will first detail each of the four programs, describing their philosophies on how engineers should undertake community engagement. Next, I will discuss an early signature project of each program. Then I will highlight how the program's philosophy about community engagement affected how it pursued partnerships. Lastly, I will discuss implications of this research for engineering educators seeking to build effective international partnership networks.

Overview of Engineering Education Programs

This paper uses four engineering education programs as exemplars in order to highlight different approaches taken by engineers who work in marginalized communities. The four programs are the Design for Extreme Affordability course at Stanford University, the Humanitarian Engineering and Social Entrepreneurship program at Penn State, the Humanitarian Engineering program at Colorado School of Mines, and the D-Lab at the Massachusetts Institute of Technology. I chose these programs because they have been integrated into institutional structures, maintain a considerable online presence documenting various projects, and have different philosophies of how engineers should undertake community engagement. I will now discuss each program's philosophy of how engineers should undertake community engagement.

The Design for Extreme Affordability course at Stanford University uses design thinking to develop products and services for people making less than $4/day.[3] Students work in teams supervised by different businesses already operating in target communities. In addition to developing a working prototype, student teams author business plans to strategize how to serve a large customer base. Several projects focus on increasing the incomes of smallholder farmers or providing assorted low-cost health care products suited to rural environments. Philosophically, the Design for Extreme Affordability course conceives poverty as caused by a lack of income.

The Humanitarian Engineering and Social Entrepreneurship program at Penn State encourages students to design social business ventures to meet basic needs of people living in poverty.[4]

Students conduct need-finding exercises by exploring how people living in various high-poverty countries use indigenous knowledge to meet basic needs. From there, students postulate ways to create business plans compatible with these ways of knowing. The Humanitarian Engineering and Social Entrepreneurship program provides support to students through business plan competitions with prizes, opportunities to study abroad in targeted countries, and organizing classes for students wanting to continue to develop promising ventures. Philosophically, the Humanitarian Engineering and Social Entrepreneurship program conceives of poverty as caused by inability to meet basic needs.

The Humanitarian Engineering program at Colorado School of Mines wants to help students construct robust definitions of *sustainable community development*.[5] Students learn about engineering's spotted history in international development as a method of stressing why engineers working in marginalized communities must pay attention to design's sociocultural dimensions. The Humanitarian Engineering program encourages students to participate in engineering service organizations like Engineers Without Borders and Bridges to Prosperity so students gain first-hand experience in determining if and how a community could benefit from a particular engineering project. Philosophically, the Humanitarian Engineering program conceives of poverty as an absence of sociocultural status needed to achieve desired community outcomes.

The D-Lab at Massachusetts Institute of Technology connects students to a network of engineers and artisans working to solve problems of marginalized communities around the world.[6] Students spend their short January course and Spring Break visiting various partners around the world to discuss assorted projects. During standard semesters, students continuously develop products and services. Representatives from the global community gather annually at the International Development Design Summit to suggest new problems, create various prototypes, and share design knowledge. Philosophically, the D-Lab conceives of poverty as a problem continuously addressed by people living in marginalized communities.

The table below highlights the goals and philosophy of each program.

	Goal	Philosophy
Design for Extreme Affordability at Stanford	Develop products and services for people making less than $4/day	Lack of money causes people to live in poverty
Humanitarian Engineering and Social Entrepreneurship at Penn State	Design social ventures to meet the basic needs of people living in poverty	Market failures can greatly reduce options available to people trying to meet their basic needs
Humanitarian Engineering at Colorado School of Mines	Empower students to undertake sustainable community development	Many communities lack sociocultural status needed to achieve desired community outcomes
D-Lab at Massachusetts Institute of Technology	Connect students with a network of engineers and artisans working in marginalized communities	People living in marginalized communities are constantly at work to solve problems within their community

Having provided a brief overview to the four engineering programs, I now will discuss the origins of each program by detailing early student projects that marked a launching point to establish the program.

Starting Small

All of these programs have relatively humble beginnings where engineering faculty connected with engineering students passionate about making a positive difference in marginalized communities. The programs grew from one early signature project by conscientious networking and learning lessons along the way.

Design for Extreme Affordability Lights Up the World

Design for Extreme Affordability began as a Social Entrepreneurship Start Up course.[7] In 2004, Stanford faculty member James Patell sought to transfer a technology to developed by the Light Up the World Foundation to large numbers of people living on less than $2.50 a day. The Light Up the World Foundation had created a low-cost LED light for use in non-electrified areas, but the technology needed to be improved and appropriately positioned within markets capable of reaching consumers living below the poverty line. Over course of two semesters, Stanford students researched and developed products with business strategies suitable for use in China, India, and Mexico.

Realizing that Light Up the World Foundation lacked the manpower necessary to advance the business, students Matthew Scott and Amit Chugh founded Cosmos Ignite Innovations to deliver the marketable MightyLight lamp to Indian consumers.[8] Scott secured venture capital for the business while Chugh coordinated with non-governmental organizations operating in India. The business worked to improve the lamp design, ultimately reducing the market cost to $25. By 2011, Cosmos Ignite Innovations had sold 150,000 MightyLights to consumers in 18 countries.

This approach has several strengths. First, products already existed that used the low-cost LED light technology. Students had comparable products to use as benchmarks when improving the design and when assessing market viability. Second, the income definition of poverty permitted students to define affordability as a key design constraint that could be measured. Students could use principles of engineering economics to test whether the product would be affordable, a skill cultivated in many other design courses. Third, the Social Entrepreneurship course gave students access to mentors already working internationally. These mentors supported the students who wanted to develop the idea into a successful business venture.

Humanitarian Engineering and Social Entrepreneurship Seeks to Export Healthcare

Mashuvu, a signature project of the Humanitarian Engineering and Social Entrepreneurship program at Penn State, works to improve rural health care access in African countries by installing telemedicine kiosks.[9] Students brainstormed the possibilities of creating a social business that connected people living in rural areas to medical expertise. Under the direction of faculty member Khanjan Mehta, student teams have traveled to Tanzania and Kenya in order to conduct various feasibility studies. The Mashuvu project received a significant amount of seed funding from an external social entrepreneurship contest in March 2008.

Mashuvu team members have engaged in extensive networking to implement the venture in Africa. Although the project initially targeted Tanzania, the team established a formal partnership with the Children and Youth Empowerment Center of Kenya in 2009. The team promptly moved primary operations to Kenya. As the Mashuvu team worked to implement the healthcare kiosks in country, they confronted assorted cultural, ethical, and legal issues. Penn State Law School started encouraging law students to join the Mashuvu team in 2009 and established the International Sustainable Development Projects Clinic. As more kiosks have been installed, Mashuvu team members have compared the effectiveness of the telemedicine kiosks to face-to-face consultations and have preliminary evidence that telemedicine connects people living in rural areas with comparable preprimary healthcare.

This project showcases several strengths of the Humanitarian Engineering and Social Entrepreneurship Program at Penn State. First, faculty encourage students to learn more about problems the significantly impact the lives of people living in poverty. When students conduct research in a domain like access to health care in rural areas, the students will likely develop greater awareness of the social context and other ethical issues. Second, the program provides continual support to students by creating classes where students can continue to develop their ideas and connecting students with other resources on campus. The Mashuvu project has expanded as more students have gotten involved with team members regularly traveling to countries that have already built kiosks. This continuing engagement allows faculty and staff working on the Mashuvu project to assess appropriate next steps.

Humanitarian Engineering Creates Courses to Prepare Students for Honduran Community
The genesis of the Humanitarian Engineering program at Colorado School of Mines differs from the other programs in that Colorado School of Mines started by designing dedicated Humanitarian Engineering courses. When creating the program, faculty worked actively to define humanitarian engineering as "design under constraints to directly improve the wellbeing of underserved populations."[4] The Liberal Arts and International Studies division hosted the early signature courses of the Humanitarian Engineering program.

David Munoz, Director of Humanitarian Engineering, coordinated a multi-stage project where students worked with a Honduran community displaced by Hurricane Mitch. Students planned the project in several stages.[4] During the first stage, people affiliated with Colorado School of Mines went to the community in order to ask what kinds of projects would best serve the community. The Honduran community identified a pressing need for a reliable and affordable water supply. Students and faculty returned to the community several times to ensure that the piping system met community needs, partnering with local non-governmental organizations capable of communicating effectively with the community.

The program has several strengths worth noting. First, courses in the Liberal Arts and International Studies division highlight how knowledge of different social science and humanities disciplines can help engineers working in marginalized communities. The program makes concrete recommendations as to what courses engineering students should take to develop important skills need when working in marginalized communities. This approach differs from an "add-a-course" model in that the program offers guidance to engineering students who already need to choose social science and humanities electives. Second, the program values developing

informed solutions when engineers must exercise their professional skills. The experience in Honduras highlighted many problems related to communicating with the community where the students and faculty tried multiple strategies to communicate effectively within the community. Third, the community had a significant voice in determining what technical problem the engineering students should work on solving.

D-Lab Helps Haitian Students Give Back to Haitian Communities

The D-Lab at Massachusetts Institute of Technology began when students from a Haitian Student Association approached Amy Smith, a staff member known for her expertise in developing technologies suited for impoverished communities.[5] The Haitian students wanted to join with other MIT students and give back to Haitian communities. Dubbed "The Haiti Class" of 2002, these international students leveraged their connections with assorted non-governmental organizations on the island and identified pressing problems among Haitians living in poverty. People living in poverty needed alternate cooking fuels as rampant deforestation had greatly reduced the ability of wood charcoal. The MIT students worked on creating a process to make charcoal briquettes from sugar cane manufacturing waste.

Smith drew upon her experience as a Peace Corps volunteer who designed innovative technologies capable of solving pressing problems. Smith had firsthand knowledge of how women in Botswana used biomass in cooking and translated relevant portions of this knowledge to the Haitian context. Because of her Peace Corps experience and continued global travel, Smith had an extensive network of contacts that designed appropriate technologies for communities in the developing world. As much as possible, Smith connected her students with a range of mentors to create stronger designs.

This project shows several strengths of D-Lab's approach. First, the Haitian students had considerable firsthand knowledge about life in Haiti. These students could make recommendations of engineers and artisans already working in the country to address this sort of problem. Second, the program values giving students first-hand experience of trying to solve the problem. As students try solving the problem with existing technologies, the students gain an appreciation for the magnitude of the problem and can identify many incremental changes that improve the design.

The observed strengths of these four programs highlight the importance of asking key questions when beginning a program that exposes students to designing for marginalized communities.

Key questions when considering your first project:

- How will students learn about the nature of the problem? Will they be working to improve an existing technology, partner with an existing organization, or attempt to create a new business venture?
- Who might already be working in the target community?
- How will students construct criteria to evaluate their design in the context of a marginalized community?
- How can students create prototypes for their designs?
- What resources are available on campus to support students learning about complex social problems?
- Where can you seek external mentors for the project?

Contemporary Pathways to Partnership

As a result of these early experiences, engineering educators learned lessons along the way that affected how they built partnership networks. The four programs encountered different obstacles and, as such, developed different models of partnership. In this section of the paper, I will describe the obstacles encountered and the networking strategy employed by the program.

Solving Problems at Scale

The Design for Extreme Affordability course provides students a platform to develop vital and affordable technologies that can meet the needs in emerging consumer markets. These ventures are frequently referred to as Bottom-of-the-Pyramid ventures as they seek to serve the population in the lowest quintile of income distribution. C.K. Prahalad made a clear business case for working in among these consumers, noting that people living in poverty often paid premium rates for basic services.[10] However, Design for Extreme Affordability first partnered with a foundation rather than an organization interested in gaining market share. Many foundations cannot adequately serve emerging customer markets. Foundations lack necessary staff, feel that distributing products to market pulls the foundation away from its founding mission, and have negotiated entry into various country contexts as not-for-profit organizations.

The original partnership with the Light Up the World Foundation did not continue into future semesters. While some Stanford students found continuing support to start their own business venture, Design for Extreme Affordability sought different organizational partners. In 2005, students designed for country affiliates of International Development Enterprises. Paul Polak founded International Development Enterprises with the express goal of creating market-led solutions that could alleviate poverty.[11] The business orientation of International Development Enterprises matched well with the ethos present within Design for Extreme Affordability.

Currently, the Design for Extreme Affordability course selects partners from among those organizations who apply to be a partner for the course. The application stresses that partners must be willing to host a team of 4 students over the Stanford students' Spring Break and should be available to communicate with students and the teaching team. Furthermore, the application requires that organizations remain open to iterative design thinking processes where Stanford students identify the best way to meet a given need rather than develop particular technologies requested by the community partner. Partners expect to receive a reasonably developed prototype at the end of course where the organization develops the design further, the organization continues to work with Stanford students in the course, or the organization provides encouragement to students starting their own for-profit venture.

The initial approach to finding partners for the Design for Extreme Affordability course was inadequate. Although the Light Up the World Foundation could benefit from Stanford students improving the existing low-cost LED light technology, the foundation could not implement the proposed business models. Design for Extreme Affordability has faculty from the Stanford Business School: failing to include social venture design in the course structure would significantly change the core learning outcomes of the course. The course needed to find partners who could mentor students as the students sought to develop original business ventures.

The Challenges of Implementing Solutions In-Country

The Humanitarian Engineering and Social Entrepreneurship program provides considerable opportunities for students to propose ideas for social ventures. The program hosts the annual Milking the Rhino: Innovative Solutions Showcase which exposes the students to the problem of developing social ventures in African countries.[12] The faculty at Penn State designed the Solutions Showcase to increase global awareness in engineering students where students do not have to travel internationally. Students view the documentary *Milking the Rhino* to learn how tribes in Africa use their knowledge to solve significant problems. Students are then asked to prepare a 3-minute pitch of a social business plan that honors indigenous forms of knowledge. The competition provides student teams an opportunity to pitch their business idea for small cash prizes. However, winning teams frequently travel internationally to test different features of their proposed solutions. In the past years, the winning pitches include considerable references to in-country travel where students actively work to build implementing networks.[13]

The Humanitarian Engineering and Social Entrepreneurship program has cultivated local partnerships. Many of the program's partners are other organizations housed at Penn State. One notable partnership is the International Sustainable Development Projects Clinic. This Clinic is housed in the law school and provides legal assistance for students implementing their venture. Law students support the work of HESE classes. Penn State also hosts a United Nations Indigenous Knowledge and Culture center. The partnership with this center provides educational support for students trying to integrate indigenous knowledge into their projects. This center provides the HESE program with many resources to help students see how indigenous knowledge might be at work in existing solutions. These Penn State partnerships expand the educational abilities of the Humanitarian Engineering and Social Entrepreneurship program by connecting faculty from many disciplines to help students implement their projects.

The Humanitarian Engineering and Social Entrepreneurship program leverages and promotes resources at Penn State. Penn State houses multiple international knowledge centers and several research labs that focus on the African continent. These knowledge centers and research labs have connections to organizations like the Children and Youth Empowerment Center in Kenya. When campuses have established international partnerships, these established partnerships might be able to support a new educational venture. Faculty associated with the Humanitarian Engineering and Social Entrepreneurship program could lead trips bringing a small number of students abroad. However, emphasizing existing partnerships might hide the development of grass-root networks needed to implement solutions[13] and may lead to recognized organizations being overwhelmed by the number of project requests.

The initial approach of finding organizational partners can help a new program achieve institutional recognition and gain support needed to send students abroad. The new program can use existing in-country partnerships instead of having to develop brand-new relationships. However, the experience of the Humanitarian Engineering and Social Entrepreneurship program shows that the new program frequently has different educational outcomes than the existing program. Specifically, HESE's experience reflects a growing concern about how students can implement their solutions in country. While creating the International Sustainable Development Projects Clinic supported teams encountering legal obstacles, many other projects have found mentors by traveling within the implementing country.

Finding Project Mentors

The Humanitarian Engineering program at Colorado School of Mines frequently needs people to mentor senior design projects. Because the Humanitarian Engineering senior design projects are offered as a part of the same courses as other senior design projects, the faculty from Humanitarian Engineering must be able to provide comparable resources to mentor student teams. While the Humanitarian Engineering program suggests that having in-country mentors would be a gold standard, Colorado School of Mines faculty with appropriate expertise frequently advise senior design teams to be able to accommodate semester schedules and the various senior design project deliverables. The Humanitarian Engineering program tries to broaden its connections with local organizations working in assorted international development fields by having an office in the Posner Center for International Development.

A commitment to working with communities has brought about a redesign of the humanitarian engineering program. In Fall 2014, the program will include courses that incorporate service learning. By making this pedagogical switch, students at Colorado School of Mines will be able to gain experience in sustainable community development by continually interacting with targeted users, organizations, and communities. The need to find project mentors who could help students communicate directly with the targeted communities spurred the Humanitarian Engineering program to think more locally when finding design projects. Moreover, the redesigned humanitarian engineering program provides a semester course devoted to the topic of "Human-Centered Problem Definition" highlighting how defining a problem with a community of people takes time and skill.

Providing Time and Space for People to Connect around the World

The D-Lab at the Massachusetts Institute of Technology has pursued an organic method for connecting with designers around the world. Whenever a representative from D-Lab travels, he or she always looks for places where local artisans gather. D-Lab encourages everyone affiliated with the program to keep an eye out for pressing problems, creative solutions, and first-hand knowledge about the problem from people living with the problem on a daily basis. The D-Lab network emerged as international students shared their knowledge of non-profit organizations and artisans working in their communities and as students visited assorted partners scattered across the globe.

However, D-Lab staff recognized that solutions would be stronger if more people from the network could gather in the same place at the same time. Towards this end, the D-Lab hosted the first International Development Design Summit at the Massachusetts Institute of Technology. The inaugural summit drew 50 people from 16 countries. Now in its eighth year, more and more people express interest in attending the summit than can be accommodated. In 2012, USAID provided funding for the International Development Innovation Network coordinated by D-Lab. This funded network connects universities already active in planning the International Development Design Summit so these universities can continue to organize and empower local artisans working to solve pressing development problems.

The success of the International Development Innovation Network also indicates the cost of pursuing this kind of partnership strategy. Building a global network of people that occasionally

gather in person involves a costly infrastructure of event planning, travel costs, recruitment, and scholarship monies to pay for people who cannot attend without subsidy.

Implications for Engineering Educators Desiring International Networks

I will conclude this paper by translating lessons learned from these four established engineering education programs to be relevant to other engineering educators. Developing an international network requires significant investment where engineering educators would do well to reflect on their philosophy of community engagement, their intended program structures, and their students. Engineering education programs can focus on building partnerships with organizations local to the university, organizations local to the target community, organizations with a large global footprint, and with individuals within the target community.

Looking first to the case of the Design for Extreme Affordability course, we see shifting strategy to pursue partnerships. Although Light Up the World Foundation had pioneered a promising LED lamp technology, the Foundation lacked capacity to help achieve the course goal of launching sustainable businesses that served people living in poverty. Additionally, Light Up the World Foundation had a relatively closed organizational mandate of providing lighting solutions where it was difficult to identify new projects with this particular community partner. The course sought a new partner in International Development Enterprises, a move that connected the students with a partner consciously working to create market-led solutions. To try and broaden the reach of the course towards other organizations, the Design for Extreme Affordability course elicits applications from prospective partner organizations. This approach to building an international partnership network can be found in consulting agencies where previous clients refer future business.

Moving to the case of the Humanitarian Engineering and Social Entrepreneurship program, we see engineering educators creating partnerships in response to problems encountered by the program. These partnerships largely build alliances between university entities with similar mandates. Additionally, several of these university entities already have international networks. The Humanitarian Engineering and Social Entrepreneurship program made sure to align their educational mission with the educational mission of these other university entities.

Continuing to the case of Humanitarian Engineering at Colorado School of Mines, we observe a program trying to work within existing university structures. While the Division of Liberal Arts and International Studies continues to offer classes dedicated to helping engineering students rigorously define sustainable community development, integrating design projects into the Humanitarian Engineering program has posed considerable difficulties. In particular, offering senior design opportunities challenged the program's emphasis on using knowledge directly from community members to define the problem. Because students working on senior design projects have important time-dependent deliverables and often need mentoring, the Humanitarian Engineering program has welcomed participation of faculty across the school with an interest in related projects as well as maintained a presence in a building with many international development organizations. The Humanitarian Engineering program redesigned existing courses to incorporate service learning, so students gained experience serving marginalized communities living locally to the university.

Finishing with the case of the D-Lab at Massachusetts Institute of Technology, we note that the program has displayed an incredible commitment to connecting designers from various communities. D-Lab students consistently travel during the short January term and Spring Break. Other engineering educators should note that not all students have the resources to take advantage of these study abroad opportunities. D-Lab works with other offices to direct students to appropriate financial aid resources and seeks additional funding to host other designers from around the world. Organizing the International Development Design Summit also provided an alternative space to bring designers together. D-Lab established its international development network by building significant relationships with individuals and creating space for them to come together.

The table below summarizes these different approaches to building partnership networks.

	Approach to partnership network
Design for Extreme Affordability at Stanford	• Seek mentors from organizations that could implement proposed solutions • Previous clients refer future business
Humanitarian Engineering and Social Entrepreneurship at Penn State	• Build alliances with existing university entities with similar missions • Capitalize on extant international networks
Humanitarian Engineering at Colorado School of Mines	• Find advisors familiar with university structure and timelines • Connect with local organizations that serve marginalized communities elsewhere • Incorporate service learning
D-Lab at Massachusetts Institute of Technology	• Build significant relationships with engineers and artisans already working to address problems related to poverty • Incorporate opportunities for students to travel and engage with target communities • Create space for engineers and artisans to gather on a regular basis

Few engineering educators can consider using all of these strategies to build international partnership networks. I chose the four case studies deliberately to highlight diverse approaches. Using discourse analysis allowed me to see how engineering education programs established their philosophy of community engagement while also identifying mechanisms that might have created difficulties in wholly implementing their philosophy.

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