AC 2012-3280: DEVELOPING AN ENGINEERING CURRICULUM AT A DEVELOPING UNIVERSITY IN A DEVELOPING COUNTRY

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Overview

Through use of an in-progress case study model, this paper sets out to demonstrate the possibility and advantages of home-grown grassroots development of an engineering program in a small developing country. The model of this case study presents an alternative approach to a resource intensive top down construction of an engineering program, likely funded by external western resources. In this case study, an existing physics program has been reshaped to include new engineering courses immediately, with a plan to add additional courses soon, creating an applied physics or engineering concentration within the physics program, and eventually a full engineering curriculum.

Background on the University of The Gambia

The University of The Gambia (UTG) was established through an act of the national government of The Gambia in March of 1999. Prior to this act, students had to go abroad to study most disciplines (programs in primary and secondary education and agriculture were available at another Gambia College). Currently the University enrolls about 2000 students, and the College enrolls another 2000. As expected in a developing country where per capita GDP is $1900 annually (in US dollars in terms of purchasing power parity, [1] UTG has very limited resources to work with. Faculty are stretched very thin (heavy teaching loads), and while the majority of the faculty are Gambian, the university also relies on several expat volunteers (US Peace Corps, and others) and full time expat faculty to cover course schedules. Few citizens of this nation have the credentials to teach at the University level, and many who do have pursued careers abroad. The resource strapped institution offers very modest faculty salaries and many faculty have second jobs (family farms, consulting businesses). This situation has made attracting faculty to UTG a significant challenge. The next generation of faculty will likely come in large part from students studying at UTG today.

The university has numerous needs; however, it is also at an amazing point in the history of the institution. The national government is currently constructing a new residential campus 10 miles east of the present campus, shared with Gambia College. The Ministry of Education is finalizing arrangements to bring the Fulbright Scholars program to UTG. Funding is in place to open a Masters Degree program centered on issues relating to global climate change. Numerous students flock to programs in applied areas of study: Business Administration, Medicine, Public Health, Computer Science, Agriculture, and Law. As a Commonwealth nation, UTG has modeled its curriculum after those in the UK, not uncommon in Africa [2].

Developing an Institutional Identity

The development of the engineering program at UTG must support the overall institutional goals. Perhaps the most strongly felt of those goals is the institution's efforts to develop a research identity to help establish itself as a university on an international stage. Ernest Boyer's model of scholarship as discovery, integration, application and teaching can be extremely useful for developing a research agenda at non-Research 1 (R1) Universities and Colleges.[3] His ideas have been incorporated into tenure expectations at many smaller undergraduate colleges in the US. While faculty at UTG (and smaller colleges in the US) will struggle to compete with the R1's in the scholarship of discovery, the playing field can be leveled or even tipped to their advantage in the other areas. Faculty at many smaller US colleges and UTG will likely always have greater teaching responsibilities and less access to costly research laboratories and resources (library, software, database access, support staff, technicians, etc.). This clearly tips the competitive balance toward the R1's in the scholarship of discovery. However in the scholarship of teaching, an increased valuation of teaching should provide opportunity to raise visibility in this area of scholarship. Evidence of this can be seen every summer at the annual meeting the American Society for Engineering Education (ASEE), where small colleges have a much higher proportional representation in technical sessions than at other professional meetings. The student work and collaborations with US based students and faculty, on local projects of service learning, represent examples of the scholarship of application. When applying new technologies successfully in the developing world, the faculty and students at UTG are at a competitive advantage over western R1 universities, due to their intimate understanding of the local culture and environment.

To achieve the research identity sought, UTG should contribute to disciplinary scholarship in areas of unique expertise. UTG doesn't have the resources to compete with international R1's in many areas of inquiry, yet in some areas less dependent on material resources, breakthroughs may be possible. Still, this should not be the focus. The playing field is not level. In other areas the balance tips the other way. Boyer's model includes taking the findings in one cultural setting and applying them in a new setting and using research findings and innovations to remedy societal problems.[4] Here is where UTG should set up their "scholarship camp" - focus work on applying the findings and innovations in the various academic disciplines in the developing world. This area of scholarship also does not have a level playing field – but this time the advantage is UTGs. Who better to find ways to "remedy societal problems" in a material resource poor developing country, than the scholars at UTG? Most faculty at US and European Universities are too far removed from the realities of daily life in a developing country to compete with UTG in this area of scholarship.

Since the faculty at UTG are clearly stretched thin, it would be advantageous for UTG to involve students in this work, side by side with the faculty. UTG students understand life in a developing country. By adding senior theses to the developing engineering program, these students can work with faculty on such problems.

Development of the Engineering Curriculum

UTG should develop programs that produce graduates suitable for employment domestically and abroad, but the focus should be on domestic employment. For domestic employment the nation needs opportunities for graduates – it needs employers with resources. Then the university needs to produce graduates with skills employers in these sectors need. The program in Renewable Energy Engineering featured in this case study should fit this model.

One profession among several lacking from the list of disciplines at UTG, which would seem vital to a developing nation, is engineering. The nation has severe infrastructure needs: roads wash out seasonally, devastating flooding occurs continuously throughout the rainy season, much of the nation is off the electrical grid, and those on the grid experience regular power outages. Food processing and other light manufacturing would provide much needed employment. Mobile phone usage has erupted throughout the country, internet cafes (while painfully slow and full of virus infected PCs) are in every village. This array of industries represents a vast curriculum of a variety of engineering disciplines including electrical, mechanical, and civil engineering, manufacturing and others. However, with a grassroots, 'on a shoestring,' approach, the current case study develops a broad general engineering curriculum from the foundation of the existing physics curriculum. University administrators and national government leaders are energized around the concept of renewable energy systems, motivated in part by the connection to the Masters Program in climate change mentioned above. A blossoming photovoltaic industry currently imports European trained engineers to design systems. Working with representatives of the Ministry of Energy along with a few private sector engineers, a general engineering curriculum focused on renewable energy applications has been developed.

Pilot Engineering Curriculum Proposal:

This program is being developed as a concentration option under the existing physics major. This allows the program to be phased in over time.

New courses implemented in 2010/11 academic year

1. PHY412 – Solar Energy (3 credits)
   - Photovoltaic System Design and Theory: Starting with the energy production of the sun, students study all aspects of a PV system and its sub-components from the Physics of the PV cell itself to the technology of an inverter.
   - Students learn to design PV systems: Grid-tied and standalone battery systems
   - To be cross listed as an engineering course
   - 1st offering was offered by US based visiting faculty, but 2nd and future offerings will be taught by current UTG faculty.

2. PHY304 – Experimental Physics 3: Engineering Design (4 credits)
   - Multidisciplinary course on full (Total Design) life cycle methodology from defining the problem to reuse and disposal ("cradle to cradle") including all aspects from performance to politics, market constraints to maintenance, etc.
   - Project-based: Designed with the context of socio-cultural respect, community participation and need, economic sustainability (local financing and cost recovery), and environmental sustainability during operation and maintenance, based upon appropriate technologies developed with as many local materials and components as possible.
   - Projects in renewable energy S2011

- Health Clinics: already have PV arrays – many non-functional; design a more sustainable model (economic sustainability) which could be replicated across country
- Community Center: existing PV system was operating well below optimum efficiency; design an improved system to meet expanded needs for lighting, power for PCs, water pumping for community farming in a way that could be scalable up or down according to available resources

- To be cross listed as an engineering course
- 1st offering was offered by US based visiting faculty, but 2nd and future offerings will be taught by current UTG faculty. Currently the 2nd offering is underway with 10 enrolled students working on new projects.

Current physics courses to be cross listed as engineering

These need to correspondingly start to include more applied problems and design applications (current UTG catalog descriptions are included below).

1. PHY302 as EGR263 Dynamics (3 credits)
   Kinematics, coordinates systems, (Cartesian coordinates, polar coordinates, cylindrical coordinates, spherical coordinates), velocities and acceleration of a point in a Frenet base, circular motion, helical motion, change of frame of reference, composition of velocities, composition of acceleration, Newtonian mechanics, Galileo transformations, terrestrial frame of reference, work, power, kinetic energy, potential energy, total mechanical energy, interaction between two bodies, central force motion, Newton's universal law of gravitation, Kepler's laws, orbits and satellites
2. PHY203 as EGR203 Thermodynamics (3 credits)
   The laws of thermodynamics describe the behavior of the macroscopic world around us. This course will introduce the concepts behind the description of bulk systems, including temperature, energy, entropy and laws of thermodynamics, Maxwell's relations and phase transition. Prerequisites: PHY 101 and PHY 102 (3 Semester hours). Textbook: Thermodynamics: An Engineering Approach. Sengel & Boles
3. PHY413 as EGR413 Heat Transfer (3 credits)
   Heat conduction in 2 and 3 dimensions, Fourier equation of heat conduction with source and without source, numerical solution of Fourier equation, thermal convection on a horizontal surface, thermal convection on a vertical surface, thermal convection in pipes, thermal radiation, emissity and absorptivity of gray bodies, blackbody radiation, heat exchangers.
4. PHY205 as EGR205 Electronics I (4 credits w/ Lab)
   Students will be introduced to the basic concepts of describing n – type and p – type semiconductors, diodes, rectifier circuits, bridge rectifier and rectifier with center tapped transformer bipolar junction transistor (BJT), small signal amplifiers, power amplifiers, junction field effect transistor (JFET), metal oxide silicon field effect transistor (MOSFET) and operational. Lectures 2x1½ hrs lecture per week and 1 x 3 hour laboratory/ practical (4) semester hours Textbook:

Advanced electronics, O. Newmen

5. PHY206 as EGR206 Circuits I (4 credits w/ Lab)

   Kirchoff's laws, superposition principle, Millmans theorem, Threvenin;s theorem, Norton's theorem, linear quadripoles, Transfer functions of quadripoles, RC circuits, RLC circuits (series & parallel), transformers – step up and step down, filters – high pass and low pass, band pass. Lectures 2x1½ hrs lecture per week and 1 x 3 hour laboratory/ practical (4) semester hours Textbook: Electric circuits – Theory & Applications, Edminister

6. PHY402 as EGR402 Electromagnetism (3 credits)

   This course introduces the equations for electric and magnetic fields in free space and in media. Techniques studied include the lap lace and Poisson equations, Maxwell's equations and an introduction to electrodynamics in free space. Textbook: Electromagnetic Theory and Wave Propagation 2nd edition S. N. Ghosh

New courses to be added as part of this program (introduced over a period of time):

1. Fluid Mechanics (3 credits) - cross list as PHY course

   Fundamentals of fluid dynamics for mechanical engineers. Topics include fluid properties, fluid statics, control volume analysis, steady and unsteady Bernoulli equation, and introduction to differential analysis of fluid flow. Laminar and turbulent flow in pipes and channels and in external flow. The boundary layer concept, life and drag. Includes an introduction to a commercial CFD package.

   *Prerequisite(s): Classical Mechanics.

   Text: Fundamentals of Fluid Mechanics by Bruce R. Munson, Donald F. Young, Theodore H. Okiishi and Wade W. Huebsch

2. Wind and Marine Power (3 credits)

   This course is an introduction to the design of turbine based power generation systems, in particular wind, hydro and tidal. The course will examine aspects of the theory, design and implementation of wind and marine power systems, with an emphasis on practical applications. Prerequisite: Fluid Mechanics.

   Text: Wind Energy Explained: Theory, Design and Application, James F. Manwell, Jon G. McGowan, Anthony L. Rogers

   Text: Alternative Energy Systems, by Hodge, B. K., Mechanical

3. Bio-Fuels and Geothermal systems (3 credits)

   This course is an introduction to the design of renewable thermal power generation systems, in particular bio-fuel systems and geothermal. The course will examine aspects of the theory, design and implementation of bio-fuel and geothermal power systems, with an emphasis on practical applications.

   Prerequisite: Thermodynamics and Heat Transfer

   Text: Alternative Energy Systems, by Hodge, B. K., Mechanical

4. Power Electronics/Grid power (3 credits);

   An introductory course in electrical energy systems; history, current trends, renewable and nonrenewable sources, rotating machine, transformers and power electronic applications, distributed generation and smart grid initiatives. Including

analysis and design of AC-DC and DC-DC converters, Linear, basic switching, transformer switching, and charge-pump topologies.
Text: Electric Machinery Fundamentals, 5th Ed., 2011

5. Senior Design Project (4 credits; 2 credits in each of 2 semesters)
   A demanding, and perhaps original, engineering project performed under close supervision of a faculty member. Students usually work in teams on the given project. Typically includes problem definition, development of requirements/constraints, preliminary designs, detail and final design report, and construction of a working prototype. Progress reports, a final report and a public seminar are required.
6. Sustainable development (3 credits - Economics and Policy – not an EGR course). A current UTG management course could be adapted for this requirement.

Supporting coursework in Mathematics and Sciences, as well as an extensive general education curriculum are not listed here.

Phasing Plan

The two new courses introduced in the 2010/11 academic year are now included as electives that count toward the existing Physics major. Modifications to the existing physics courses toward applied applications are underway. With a few of the new course additions, a Renewable Energy concentration will be added as an applied physics option under the existing Physics major. Finally, adding all the additional courses will bring the program up to 48 credits of engineering course work and create a new major in Renewable Energy Engineering.

2010/11 Course Experience

Most UTG students have done few, if any, open ended assignments, and most have never worked on a real world project. The emphasis of UTG course grades is placed on the final exam (with at least 50% of the course grade mandated for the final exam). Introducing a community based service project as part of their academic program was novel, although not a unique move. To increase practical training of students, Computer Science has had early success implementing a program where students and recent alumni complete paid projects for external clients (see UTSWEB, sites.google.com/a/utg.edu.gm/utsweb/). The UTG students strongly responded to the community based projects – they were eager to contribute to the wellbeing of their communities, also observed in a service learning program at a university in Ghana. [2] Similar to students from the University of Trinidad and Tobago, [5] prior to the design course UTG students did not see the connection between their studies and the ability to help people in their communities.

In the fall, the PV system design course was offered. Twelve UTG students completed this course. Students were highly energized by the practical applications offered in this course, even though they struggled with the higher than typical workload. In the spring, students complained that the spring design course was "like taking 10 courses," in terms of semester workload – but they responded very well and were eager to take their experience into other projects. One student earlier in the semester asked if he could use what he was learning this semester to address a similar problem in his own village. At the end of the term the students identified numerous projects in need of good solutions. Two students also approached the instructor about starting a "group" to work on similar projects. This group is taking shape in a structure similar to UTSWEB, with a small micro-financing account for providing upfront costs for projects when needed by the community. The design is to provide interest free loans for upfront costs for projects. However, our intention is to utilize local resources and not fund projects with western fundraising.

International Collaborations

The guaranteed availability of the new engineering courses and shifting the focus of existing physics courses toward application will be instrumental in attracting engineering students from the US and Europe to UTG. While there is significant interest in Engineers without Borders (EWB) type projects in the country, students in US engineering programs have proven reluctant to participate in a study abroad program at an institution that does not offer a full engineering curriculum. However, the benefits of the engagement of engineering students with students at UTG would be extremely valuable to both groups.

UTG would be very interested in any faculty looking to spend one or two semesters teaching in The Gambia. Really faculty in any discipline would be welcome. There were 11 expat faculty working at UTG during the 2010-2011 academic year. Soon Fulbright grants should be available for faculty interested in working at UTG. Also, opportunities exist without Fulbright sponsorship. UTG will provide appropriate housing, and while travel to and from The Gambia is expensive, living expenses in country are low, if you are willing to live a middle class local lifestyle. Living expenses for a family of four (2 grade school children) are approximately $1500/month, for a moderate (luxurious by local standards) local lifestyle.

Two options are available for hosting students from the US at UTG. The first, hosted by St. Mary's College of Maryland, predates UTG. The fall semester program is highly structured and may not work well for most engineering students. However the spring Service-Learning semester may work well, coupled with a community based project in the design course. Originally developed at Juniata College, the Keystone Study Away Consortium or KSAC program is a newer program currently offering opportunity for study at UTG every spring semester. Students take one course on West African cultures, but are otherwise free to take any combination of courses offered at UTG.

Engineering Service Projects

Service learning has been introduced into engineering programs to "increase student recruitment and retention, teach engineering ethics, encourage social awareness, introduce engineering to first year students, increase appreciation of the engineering profession, provide a quality design experience that emphasizes both technical and non-technical skills."[6] It has been demonstrated that even students not participating in an International Service Learning Design Project, but whose peers did participate, were more likely to "feel…inspired to help others." Non participants responded favorably to this survey question 3% of the time when these projects were part of the curriculum and 1.7% of the time before (participants responded favorably 4.8% of the time.)[7] Students in local service learning projects have shown a positive response to service learning projects as worthwhile and felt "motivated to make community service a vital part of their future."[8] Service learning is now seen by some as an important component in the "internationalization of engineering education."[5, 9, 10]

Introducing engineering design and service learning into the curriculum at UTG is one important aspect of this project. For all students in the program, both US and Gambian, these community service multi-disciplinary, cross-cultural design projects lead us toward "understand[ing] and respect[ing] justice, equity, fairness, and equal opportunities as virtues and values that should not be viewed as assumed universal truths, but important and contested goals and ends in our dialogues that also accept different traditions,"[11] and make connections across "disparate concepts, fields, or contexts."[12] Their work should also lead to increased awareness to their responsibilities to their communities, both locally and globally.[13] Community based service learning has been identified as particularly effective for studying sustainability.[14] Supporting this learning, students in either of the two available study abroad programs live in the local community.

Curriculum Development as an Engineering Service Project

Many times engineering service projects are not based on long term integrated relationships but are rather modeled as surgical quick fixes. Nieusma and Riley's experiences with two major engineering service learning initiatives led them to believe "real change takes years, even decades, not weeks of assistance, plugging into existing projects managed by local organizations has far more potential to contribute to real change." Further they point out that Engineers without Borders clearly seems modeled on Doctors without Borders. Engineering is not like medicine – it must be embedded, not autonomous, more like public health: "final solutions are rarely achieved, but each partial solution makes people's lives better." Engineering is not a surgical strike: get in, solve the problem, and get out. Agencies need to ask who benefits from a service learning project – who are we serving and at what cost (paid by whom)?[15]

The grassroots approach to the development of the curriculum in this case study represents an intentional effort to listen and work with the faculty in the developing country, rather than dictating the proper way of building a curriculum from an external western point of view. "Bryant Meyers in <u>Walking With the Poor</u> and others have pointed out, we in the West suffer from a tendency toward a "god complex." We want to be able to fix everyone else's problems."[16] Rather than swooping in from the west to save the day, this program is built around solving these local problems in the trenches with the local students and faculty. Nobel Peace Prize recipient Terry Waite highlighted the importance of providing opportunities for our students to work, live and study side by side with individuals of other cultures, to the end of becoming effective peacemakers in the world.[17] The training of the local students will also provide a local support network connected to the projects and the continued relationship between US engineering programs and UTG will encourage a long-term perspective. A "working relationship with the university and students in the host country would be beneficial to all involved" as it would encourage a long term relationship and help achieve a solution where the community served would be better able to solve their own problems and sustain any project benefits after the life of the project.[18] A long-term relationship with UTG will significantly enhance the impact of the work we do with the local communities (see companion paper at this meeting ASEE 2012). In far too many cases humanitarian service projects have resulted in little productive change, because of a short sighted vision not integrated with the community. [16] These truths speak both to the project based learning activities in the curriculum and the development of the curriculum itself.

The National Academy of Engineering supports this claim through the findings of their report on Engineering in the new century (*The Engineer of 2020*) – the alumni magazine for the University of Michigan reflected beautifully on this report: "Engineers in 2020 must…understand the world and the problems people have living in it…good engineers don't solve problems in a vacuum…engineering and public service will be faithful partners." [19] Practical Action (UK NGO) realizes the overwhelming majority of new technology is developed to "satisfy the consumer wants of the rich and not the needs of the poor." They strive to "Find out what people are doing and help them do it better." They design interventions to work side by side with the poor to help them solve their own problems. [20] In interviews with NGOs operating in Tanzania, Thode, et. al. found that while community participation was a challenge, increased participation increased the likelihood of project success. They recommend working with an embedded NGO that "[understands] the community and [has a] strong relationship with community leaders" combined with "setting measureable goals" and emphasizing "communication and flexibility in all parts of the project." [21]

Others echo this refrain. "Projects should be formulated at the grassroots, in the communities which are (hopefully) to benefit," "the aid worker must be in the field with local people…talk [the project] over with the local blacksmith and listen to his suggestions." Program administrators must ask "will the benefits be sustainable after we leave?" "The local community must understand the need for … long term maintenance and demonstrate **their** long-term ability to come up with [necessary funding,]" emphasis mine. [22] Even in the case of relief aid "development work should be concerned with long-term sustainability… [and] should identify and address the vulnerabilities of the people with whom they work and ensure that these are reduced over time. Relief and development should be more concerned with increasing local capacities and reducing vulnerabilities than with providing goods, services or technical assistance. In fact goods and services should be provided only insofar as they support sustainable development by increasing local capacities and reducing vulnerabilities." [23] Significant damage can be done by aid programs that do not engage a social justice pedagogy, examining "the structures and systems in which we all participate" that create the gross material differences encountered. [24]

Nieusma and Riley identified three non-technical social justice dimensions critical to success in engineering-for-development projects: social power relations, constraints of international economic policies, and project ownership and long term sustainability. [15] We are able to break the social structures' power relationship by coming into the project as a non-expert, learning side by side with students and faculty in the developing country. Working below the level of international economic policy at the grass roots level using local resources can help address the second and third concerns. Riley designed a course (Engineering and Global Development) with a facilitative instructor rather than an expert as a model for the students' engagement with the community, but noted that to achieve that goal a commitment to a long term relationship seemed necessary, and structures, such as a mechanism for the students to serve as apprentices within the community, to facilitate a two way transfer of knowledge. [9]

Conclusions

A model for developing an engineering curriculum from the grassroots in a developing country is presented. The model has been developed around a local interest in renewable energy technologies and is built upon the foundation of an existing physics curriculum at a young university. The university has very limited resources and this model uses an approach based on working within those local resources. This case study in progress has been developed around a structure of peer to peer collaboration between Gambian and US based faculty and students. The vehicle for that collaboration has been community based service learning projects. These projects also support the universities' efforts to develop its identity as a university, around the scholarship of application. The development of this curriculum is underway and will continue to progress over the next several years. Many opportunities are available for faculty and students to participate in this collaboration.

Works Cited

1. Central Intelligence Agency. The World Factbook 2009. www.cia.gov/library/publications/the-world-factbook/index.html (accessed Jul 15, 2011).
2. Ofosu, W. K.; Sekyere, F. Using Service Learning in an Engineering Program in Ghana. *International Journal for Service Learning in Engineering* **2008,** *3* (2), 42-49.
3. Boyer, E. L. *Scholarship reconsidered: Priorities of the professoriate;* Jossey-Bass, 1997.
4. Nibert, M. Boyer's Model of Scholarship. Module in Faculty Guidebook. , 2007. Pacific Crest. www.pcrest.com/PC/FGB/BoyerModel.pdf (accessed Apr 12, 2011).
5. Oakes, W. Creating Effective and Efficient Learning Experiences While Addressing The Needs Of The Poor: An Overview of Service-Learning in Engineering Education. *American Society for Engineering Education*, 2009.
6. Al-Khafaji, K. Learning Sustainable Design through Service. *International Journal for Service Learning in Engineering* **2006,** *1* (1), 1-10.
7. Johnson, P. Direct and Indirect Benefits of an International Service-Learning Design Project: Educational Effects on Project Members and Their Peers. *International Journal for Service Learning in Engineering* **2009,** *4* (1), 15-30.
8. Dukhan, N.; Schumack, . M. R. Reflection-based assessment of service learning in undergraduate engineering. *International Journal for Service Learning in Engineering* **2010,** *5* (2), 32-43.
9. Riley, D.; Bloomgarden, A. H. Learning and Service in Engineering and Global Development. *International Journal for Service Learning in Engineering* **2006,** *2* (1), 48-59.
10. Mehta, Y.; Sukumaran, B. Integrating Service Learning in Engineering Clinics. *International Journal for Service Learning in Engineering* **2007,** *2* (1), 32-43.
11. Braskamp, L. Developing Global Citizens. *Journal of College & Character* **2008,** *10* (1).
12. Taylor Huber, M.; Hutchings, P.; Gale, R.; Miller, R.; Breen, M. Leading Initiatives for Integrative Learning. *Liberal Education* **2007,** *93* (2).
13. Harward, D. Engaged Learning and the Core Purposes of Liberal Education. *Peer Review* **2007,** *93* (1).
14. Forrant, R., Silka, L., Eds. *Inside and Out: Universities and Education for Sustainable Development;* Baywood Publishing Company, 2006.
15. Nieusma, D.; Riley, D. Designs on development: engineering, globalization, and social justice. *Engineering Studies* **2010,** *2* (1), 29–59.
16. Jeske, C. Acting Above Us (Mar 12), 2010. Into The Mud Blog. www.intothemud.com (accessed 2011).
17. Waite, T. *Presentation to faculty during his visit as the Ware Lecturer on Peacemaking;* Elizabethtown College,

2010.

18. George, C.; Shams, A. The Challenge of Including Customer Satisfaction Into the Assessment Criteria of Overseas Service-Learning Projects. *International Journal for Service Learning in Engineering* **2007,** *2* (2), 64-75.
19. Michigan Engineering, at Your Service: Working for the Public Good. *Michigan Engineer,* Fall 2009, 2-21.
20. Mission Statement. www.practical action.org.uk (accessed Jun 25, 2011).
21. Thode, A. G.; Landick, K. D.; Paterson, K. G.; Watkins, D. W. Analyzing Methods to Achieve Successful Development. *International Journal for Service Learning in Engineering* **2011,** *6* (1), 94-103.
22. Hammer, M. Why Projects Fail. *Ceres* **1994,** *145* (Jan/Feb), 32-35.
23. Eade, D. *Capacity-building: an approach to people-centred development;* Oxfam, 1997.
24. Simpson, K. Doing Development: The Gap Year, Volunteer-Tourists, and a Popular Practice of Development. *Journal of International Development* **2004,** *16,* 681-692.