Proceedings of the IETEC'13 Conference, Ho Chi Minh City, Vietnam. Copyright © John Tharakan, 2013

Service Learning, Appropriate Technology and Capacity Building through Engineering Education

John THARAKAN
Howard University, Washington DC, USA
jtharakan@howard.edu

ABSTRACT

In this paper, we suggest a model whereby service-learning (SL) activities, integrated into engineering curricula, demonstrate the potential to leverage engineering education to engage in community capacity building. SL involves the engagement of students in service activities that are course-based and credit bearing, and which combine service experience with rigorous academic work. Students' participation in the service activity is conducted within an academic framework, providing students the opportunity to engage in guided reflection and formalizing their SL experience. The paper also posits that the lack of engagement of educational curricula and institutions by governments in developing countries has resulted in under-development. Failure to leverage national educational efforts to enhance capacity building has resulted brain drain, underdevelopment and reduction in capacity for sustainable development. We demonstrate the capacity building in a rural Kenyan community through an Engineers Without Borders implementation project. The project was focused on addressing water quality and quantity issues the community suffered from. This implementation visit followed earlier EWB-HU assessment visits. It was developed within the context of independent study service-learning courses focused on water sourcing, storage, treatment and conservation technologies. This paper follows earlier works that (1) argued for integration of community based service learning courses into engineering curricula, (2) demonstrated how such a course was part of a renewable energy implementation project in rural Senegal, and (3) demonstrated that capacity building should be a design outcome for service projects. Here, we argue that capacity building can be realized by leveraging service learning from academic settings. We also note the lack thereof in development discourse. We demonstrate that leveraging teaching and learning of youth can rapidly provide enhanced capacity for engagement in sustainable development work. Finally, it is suggested that broad implementation of such models across engineering programs in developing countries can lead to substantial increases in capacity building, with the potential to provide necessary interventions leading to sustainable development.

Keywords: *Service Learning, Capacity Building, Engineering, Education, Community, Sustainable Development.*

INTRODUCTION TO SERVICE LEARNING

The definition of Service Learning, or SL, is an academic and/or curricular activity that is both course based and credit-bearing, and that includes two major components: engagement of students in a self-selected, driven and planned, but professionally and academically supervised and mentored, service activity, *and* an opportunity and requirement to engage in scholarly reflection and writing on the service activity in an academic context (Bringle and Hatcher, 2007; Bringle et al, 2004). Service learning has been deemed of great value to a diverse set of stakeholders, delivering benefits of academic and experiential nature to students, faculty, community partners, and society in general. It has been shown over the past several decades that SL experiences promote independent and critical thinking skills and greatly improve educational outcomes (Eyler & Giles, 1999, 2001).

In our earlier work on SL (Tharakan, 2011), we described the extension of Engineers Without Borders project activities into an academic service learning experience that could be incorporated into regular engineering curricula. As demonstrated in that paper, engineering programs had space for incorporation of service activities into their academic curricula. This could be done through development of focused, independent study courses. Here, the student service volunteer would work closely with a faculty member to configure an academic credit bearing course of study, where the science, engineering and technology of the student service project would be the focus of study. A follow-up paper (Tharakan, 2012) described this in the context of a renewable energy implementation project that students had engaged in as part of a broader research project (Tharakan et al, 2008). It was also previously shown that the potential for capacity building would be enhanced with service activities undertaken with full engagement of the community; this resulted in the creation of cadres of community members focused on building their own capacity (Tharakan, 2012).

In this paper, service learning integrated into engineering curricula is proposed as a model for capacity building in developing countries. Service learning and capacity building are discussed and developed as a potential benefit from service learning projects that normally would not be tapped for community capacity building. The paper utilized the example of an Engineers Without Borders service project to illustrate the methodology that would be employed. Based on the results obtained, the paper argues that capacity building from the ground up in these diverse developing countries can be dramatically enhanced and expanded if curricular community-based service learning experiences are made a part of regular engineering, technology and social science program curricula.

CAPACITY BUILDING

The term "capacity building" has become a buzz word in the development field. It is grounded in the fundamental idea that real sustainable development will only take place if the capabilities of the community are enhanced and expanded. This gives the community the capability, whether in terms of training, knowhow, or skillsets, to address their own developmental needs from the ground up. Capacity building refers broadly to a conceptual approach to development that focuses on understanding the obstacles that inhibit people, governments, international organizations and non-governmental organizations from realizing their developmental goals while enhancing the abilities that will allow them to achieve measurable and sustainable results.

The United Nations Development Program (UNDP) was an early initiator and proponent of the idea of capacity building since the early 1970's. UNDP defines capacity building "...as a long-term continual process of development that involves all stakeholders; including ministries, local authorities, non-governmental organizations, professionals, community members, academics and more". Capacity building uses a country's human, scientific, technological, organizational, and institutional resources and capabilities. Capacity building can take place on individual, institutional and societal levels. At the **individual level** capacity-building requires the development of conditions that allow individual participants to build and enhance existing knowledge and skills (UNDP, 2006). At the **institutional** level, capacity building will require existing institutions within a developing country to engage in the process, including modernizing, upgrading and renovating existing institutions and developing a strong and robust support framework that includes assisting them in forming sound policies, organizational structures, and effective methods of management and revenue control. **Societal** level capacity building is broader and requires dispersion of greater amounts of capital and intellectual resources. **Organizational** capacity building refers to the process of enhancing an organization's abilities to perform specific activities. An Organizational capacity building approach is used by NGOs to develop internally so they can better fulfill their defined mission (Eade, 2005) integrating self-reflection, critical assessment and self-evaluation (Kaplan, 2000).

METHODOLOGY AND APPROACH

Bringing service learning into the suite of tools available to address capacity building efforts is a natural fit. Doing this through the framework of an engineering education program has critical relevance, especially to developing countries. Here, large populations of university students, especially in engineering programs, are underserved and underutilized. Kapucu and Petrescu (2006) have demonstrated the success of service learning for capacity building exploring the history and characteristics of service learning at University of Central Florida and Eastern Michigan University. They present service learning as one way for the community and institutions of higher education to engage in capacity building. Although not a systematic scientific inquiry, the paper is a critical presentation of field experience and demonstrates the importance of service learning for the capacity building in a community. The focus is the promotion and sustenance of the common good through civic engagement. This, in turn, builds social capital. SL projects help to foster development of a sense of caring about others, positively impact civic participation. It sustains social capital and hence everybody involved in the service-learning learns; social capital is developed, and community capacity is built.

The approach in this paper is founded on the argument that engineering service projects which are community centered while extending engineering curricular content outside the laboratory and classroom, will engage communities in addressing development problems; hence it will foster capacity building in the target community.

The methodology employed to build community capacity was through the integration of capacity building mechanisms and strategies into the Engineers Without Borders service learning projects. This required that faculty and students on the service project design their interaction with the community to include capacity building elements. The rationale for this methodology was that the community would be empowered to address their own development needs in the longer term.

A recent implementation site visit of the EWB-HU Student Chapter (EWB-HUSC) will serve to illustrate this approach. Here, capacity building is a dedicated project design target, and was integrated into the project implementation plan. The EWB-HU SC recently conducted an implementation visit as a follow-up to an earlier assessment visit to engage with the Choimim community in the Nandi Hills region of northwestern Kenya. The earlier assessment visit resulted in the community requesting EWB-HUSC intervention to address the dire water quantity and quality resource issues in the area. Thus, the implementation visit focused on addressing the community-prioritized need for improved water quality and quantity.

The project implementation design plan included time set aside for the EWB-HUSC team to work with the community and engage the selected community members in the knowledge transfer that would build their capacity. The EWB-HUSC team designed and developed educational modules to educate the selected community members on clean water production and source water collection technologies. The approach included the identification and selection of a set of community members who would engage in the training and knowledge and technology transfer. These community members were selected based on their willingness to be actual partial monetary contributors to the project.

It has been well established that development initiatives are more sustainable when the community that is a target of the intervention buys into the intervention and makes a real commitment to it, either in terms of a partial cash contribution or in terms of providing the labor or materials to support the intervention. Those community members who made a monetary contribution (5% of cost) to receiving the biosand filters (BSFs) demonstrated that they had bought into the project and the technology. These community members, who were personally willing to invest in the biosand filters that EWB-HUSC was going to install, were selected to be part of the training and knowledge transfer sessions and to become designated as community engineers (CEs). The educational modules focused on three popular different methods of water purification, including boiling, treatment with chlorination tablets and then the BSF process. Water collection training included training on wells, water pumps and rainwater harvesting.

Figure 1: EWB-HU Student Chapter conducting an education, knowledge and technology transfer session with selected community members who would be designated as community engineers.

The project design and approach had the EWB-HUSC team engage with an in-country NGO in sourcing materials locally for the implementation. The plan called for the team to do the fund raising required for financing of the purchase of components for ten BSF systems. The in-country NGO assisted the EWB-HUSC team in obtaining and transporting the materials for the assembly of the BSFs to the community site. These BSF components were transported and stored in a central location within the community. The central location chosen was NGO that was based in the community and was dedicated to engagement and service to the community and had become an integral part of the community.

The BSF components, including the shells and the filter materials, were then transported to the individual CE's homes. Here, the CE's and the EWB-HUSC team, worked together to assemble and deploy the individual BSFs. The development within the community of a set of "community engineers" capable of assembling, installing, operating and maintaining the implemented technology was posited to be the mechanism by which the project would result in the building of capacity within that community.

The initial assessment of the BSF's installed at the CE's homes was conducted by the EWB-HUSC team. Input and output water samples were collected and analyzed for pH, total suspended solids and for fecal coliform and *E. Coli.* The CE's and the NGO representatives were then trained in the water analysis. Hence, these CE's are now engaged, along with the NGO representative, in monitoring and evaluation of the functionality of the installed BSF's. The CE's, through the training sessions, knowledge transfer sessions, the BSF assembly exercises and water quality evaluation sessions, are now empowered to expand and dispersing the BSF technology to other members of the community. This will further building capacity.

To address water quantity issues, the community was trained on the rainwater harvesting technology. There had already been some RWH tanks installed in the NGO. The EWB-HUSC implementation visit included the installation of two additional 10,000L tanks that greatly enhanced the community's water storage capacity and hence addressed the water quantity challenge.

RESULTS AND DISCUSSION

These service activities were built around Engineers Without Borders-USA[1] (EWB-USA) projects that the of Engineers Without Borders Howard University Student Chapter (EWB-HUSC) were engaged in[2]. The focus of the EWB-HUSC projects were the development and implementation of rainwater harvesting systems and BSF water filtration systems in a rural community in Kenya that suffered from water quantity and quality issues.

The results of one of the critical water quality tests for a BSF that was installed in an orphanage building in the community are shown in Figure 1 below. This basic test for the presence of pathogenic E.Coli bacteria demonstrated that the BSF's were functioning.

The results from the BSF installed during a previous EWB-HUSC implementation visit in May 2012 demonstrate that the BSF has the capability to significantly improve water quality. It also demonstrated that the community engineers who had been trained in the installation, operation and maintenance of the BSF had managed to keep them operational at optimum functional capacity during the whole year following the implementation.

These service site visits of EWB teams to communities in need demonstrate a model for academic and curricula-based service learning experiences that could be incorporated into standard engineering curricula. This has been proposed as a mechanism to expand the capacity building pool and provide all students in an engineering program with the benefit of these types of experiential and service-based educational activities. Those studies also demonstrated that capacity building within the communities served was possible if the service learning project was design and developed with appropriate mentoring that ensured that community education, outreach, engagement and empowerment was an integral part of the service project design and implantation plan. Community engagement has been shown to be critical for development intervention sustainability and

[1] http://www.ewb-usa.org
[2] http://www.howard.edu/kenya

success (Verahren et al, 2012; 2013), as outlined in the survival ethics models for development with the engagement and partnership of educational institutions integral to the success and sustainability of these interventions.

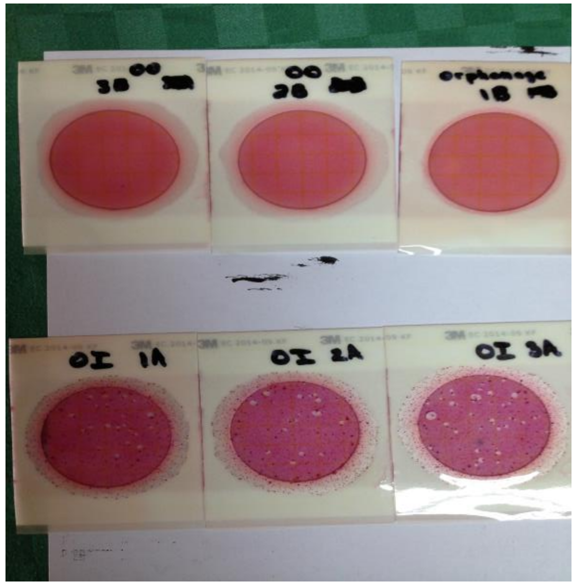

Figure 2: *E.Coli* and fecal coliform test on input (lower panel) and output (upper panel) water from the BSF installed at an orphanage house in the community demonstrating complete removal of high load of *E. Coli*.

In this instance, the service learning engagement of the EWB-HUSC team resulted in the community of Choimim village building their own capacity to address their water quality and quantity resource issues. This is a model that should be considered in universities and colleges, especially in developing countries.

It is interesting to note that this model is not unique. The model has been well established in Cuba, where their premier engineering and technology institution, has students in engineering programs conduct their senior design projects in communities (Tharkan et al, 2005). Senior design projects have to address real problems faced by a selected partnering community, and the student design team has to work with the community to develop a real and implementable solution to the community problem. This institution, CJUAE in its Spanish acronym, has been a path breaker in taking engineering education outside the university's walls and making it relevant to society and the community at large. Having senior design projects in all engineering departments require community engagement and real world problem solution provides the global engineering context and "real world" experience that engineering students need to make them feel relevant and an integral part of sustainable development. If such a model were implemented in all engineering programs in developing countries, there would be tremendous potential for capacity building and improving the quality of life for developing communities.

In the instance of the EWB-HUSC, this was not a mandatory or required part of the students; engineering programs or curricula. Nevertheless, the students engagement in these service activities, and the transformation of the service activity into a formal service learning project, excited the students and made them feel more relevant to being part of the solution to the problems being faced by developing communities. The students feel that they are part of the solution and moreover they realize the potential that they have and are capable of bringing to bear in terms of addressing real world problems in development. In the particular instance of the EWB-HUSC implementation visit to Kenya, the built capacity addressed water and health issues that the community had with water quality and quantity, and developed the capacity within the community to address their own needs.

CONCLUSION

Service Learning has been discussed in the context of community development projects that are engaged in by student volunteer groups from the engineering and technology disciplines. It was previously demonstrated that service projects that had been extended into academic credit bearing independent study courses could positively impact quality of life issues in underserved and rural communities. Here, we have demonstrated how that service project, supported by an SL course in the student's engineering curricular program, has been able to impact community capacity building efforts positively, through providing technology transfer and training that has been vetted through adequate and appropriate mentorship and professional guidance built into the SL independent study course. What is suggested, and what reaffirms earlier indications, is that the SL pedagogy, appropriately implemented in engineering curricula across educational institutions and programs, could have tremendous potential to positively impact community capacity building efforts from the ground up. Channelling the energy of our youth through appropriate academic guidance and mentoring should be an integral component of national capacity building policies and strategies.

REFERENCES

Bringle, R. G., Phillips, M. A., & Hudson, M. (2004). The measure of service learning: Research scales to assess student experiences. Washington, DC: American Psychological Association.

Bringle, RG and JA Hatcher, "Civic Engagement and Service Learning: Implications for Higher Education in America and South Africa", Education as Change, 11 (3) Dec 2007, Special Issue: CSL.

Eade, Deborah, (2005). *Capacity-building: an approach to people centered development*. UK and Ireland: Oxfam UK and Ireland. pp. 30–39. ISBN 0-85598-366-3.

Eyler, J., & Giles, D. E. (1999). Where's the learning in service-learning? San Francisco: Jossey-Bass.

Eyler, J., & Giles, D. E. (2001). At a glance: What we know about the effects of service-learning on college students, faculty, institutions, and communities, 1993-2000. Retrieved 10/14/09 from Campus Compact Web site:

http://www.compact.org/resources/downloads/aag.pdf

Kaplan, Allan (Aug 2000). "Capacity Building: Shifting the Paradigms of Practice". *Development in Practice*. 3/4 **10** (10th Anniversary Issue): 517–526. doi:10.1080/09614520050116677.

Kapucu, N and C. Petrescu, (2006) "Capacity Building Through Service Learning,"
Academic Exchange Quarterly, Vol. 10, No. 1.

Tharakan, J, "Potential for Implementing Renewable Energy Projects through Service Learning Engineering Education Experiences," in Momoh, J. (ed) *Proc. Intl. Conf. Power Systems Operation and Planning – Sustainable Energy Development*, pp.178-183, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya, January 2012.

Tharakan, J, M Mitchell, J Moore and G Jenkins, "Design of a Combined Solar Energy System for a Remote Flux Tower and a Rural Community," in Tharakan, J. and J. Trimble (eds) *Proc. 3rd Int'l. Conference on Appropriate Technology, Kigali, Rwanda, November 2008(ISBN 978-1-60725-559-8)*, pp. 51- 58.

Tharakan, J., "Institutionalizing a Student-Centered Community-Based Service Learning Engineering Education Experience," *Proc. Int'l Engineering and Technology Education Conference, IETEC 2011*, Kuala Lumpur, Malaysia, January 2011.

Tharakan, J., "Service Learning in for Capacity Building in Appropriate Technology for Sustainable Development,", *Proc. Int'l.Conf. Sustainable Development and Governance, Amrita University*, Coimbatore, India, December 2012.

Tharakan, J., M. Castro, J. Trimble, B. Stephenson, and C. Verharen, "Diversifying Engineering Education: A Seminar Course on Ethics and Philosophy of Appropriate Technology," *Global Journal of Engineering Education*, 9 (2), 2005.

United Nations Committee of Experts on Public Administration (2006). "Definition of basic concepts and terminologies in governance and public administration". *United Nations Economic and Social Council*.

United Nations Development Programme. "Supporting Capacity Building the UNDP approach". UNDP 2006.

Verharen, C, J. Tharakan, G. Middendorf, G. Kadoda, and F. Bugarin, "Survival Ethics in the Real World: the Research University and Sustainable Development, "*J. of Science and Engineering Ethics*, Published online, April 2013.

Verharen, C, J. Tharakan, G. Middendorf, G. Kadoda, and M. Castro, "Introducing Survival Ethics into Engineering Education and Practice," *J. of Science and Engineering Ethics,* **13,** December, 2011.