7. INTEGRATION OF STUDENT-CENTRED AND COMMUNITY-BASED SERVICE LEARNING EXPERIENCES INTO ENGINEERING CURRICULA

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Abstract

In this paper, we report on the incorporation of a student centred and driven community based service project into the engineering curriculum. Service learning (SL) can be formally defined as engaging students in a course-based, credit bearing and educational service experience in which students participate, and, as importantly, providing a structured framework and context, within which the students can engage in guided reflection on their service activity. An Engineers Without Borders (Howard University Chapter – EWB-HU) site and project assessment visit was conducted to a rural location in the Choimim District of western Kenya in December 2010. Two students from the team initiated and developed academic independent study projects following their service experience by undertaking guided independent study to pursue reflection, analysis and further development of their service learning experiences. One student expanded on the focus of the EWB-HU project which was the design and development of a sustainable water supply system for a community orphanage and school. The second student proposed the development of an elective course focused on appropriate technologies for sustainable development. The outcomes from these two independent study projects not only enhanced the students learning and engagement but contributed substantively to the formal and rigorous reflection required to transform simple service activities into true learning experiences. The outcomes, also suggest a model to be deployed for students who participate in EWB type service activities to gain academic credit for their service. Any model so deployed should focus on enhancing the students' applied and practical knowledge and experience gained through the service, while enabling the students to benefit academically, as well.

1. Introduction

Service Learning, or SL, has been formally defined as academic and/or curricular activities that are course based and credit-bearing, and have two major components – (1) engagement of students in a (usually) self-selected, planned and driven, but professionally supervised and advised, service activity, and (2) an opportunity and requirement to engage in reflection and writing on the service activity (Bringle et al, 2004). Critical reflection is the process whereby the student or the participant in the service learning experience, connects their service activity to their academic curricular content and makes meaning out of the combination of service experience and academic rigor.

Critical reflection requires a continuous evaluation and assessment of the service activities. These evaluations and assessments must be connected to the academic curricular content of the students academic program and contextualized by the student under the close

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supervision and guidance of the academic advisor and the service activity faculty or professional mentor. Continuity of reflection requires that there be reflection before, during and after the service activity. To connect the service, it is the responsibility of the advisor and the students to connect the service content to program objectives and outcomes.

Critical reflection requires that the reflection be contextualized within the program educational objectives and outcomes and it should be designed to generate learning by applying theory to practice, examining causality and raising questions. Critical reflection should deepen learning, iteratively asking "why" to enhance learning and comprehension. Finally, the critical reflection should document the learning through production of evidence of **learning so** that this can be assessed independently (Jacoby, 2009).

The value of service learning has been anecdotally championed and trumpeted across diverse stakeholder groups, including students, faculty, community partners, the University, society, in general, and employers. Over two decades of research demonstrate that high quality service-learning experiences enhance student learning outcomes and engage students more deeply in the educational experiences, providing for independent thinking, self-development of resources and general enhancement of educational outcomes (Eyler & Giles, 1999, 2001).

Virtually, all definitions of service-learning refer to an organized educational experience that both meets needs of the community and fulfills learning objectives of the educational program. However, for the purposes of this paper, service-learning also incorporates credit-bearing courses that include reflection activities that connect the student's experience with course content and the wider discipline (Bringle & Hatcher, 1995). There are many models of service learning that can be employed for the integration of engineering service experiences into academic curricula for credit. These include courses where service learning is optional, courses where a service-learning component is integrated as a fourth credit component for a normal 3-credit course, an internship model of service learning, field work based service learning, community based research, or a capstone-type service learning experience (Bowen, 2007; Cress et al., 2005; Heffernan, 2001; and Jacoby, 1996).

Engineers without Borders[2] is a national and international service-based organization with multiple roots, focused on improving the quality of life by providing focused and team based community development projects incorporating sustainable and appropriate technologies. Numerous professional chapters of EWB now operate in countries and cities around the globe, and scores of chapters have sprouted up in college campuses across the world. These campus chapters are harnessing the millennial generations expressed need to be part of the solution to the basic problems and issues facing developing communities, and to address critical energy, environmental and other development needs of underserved and less-developed communities around the world. These campus chapters, along with the support provided by faculty advisors, and by university administrations eager to demonstrate their responsiveness to these student-initiated needs, have synergistically combined service with education, attempting to leverage student classroom training into community-based and service driven accomplishments that have tangible results for the communities being assisted.

Service Learning Experiences at Howard University

Students at Howard University do not have a formal service-learning curricular option. Student organizations, such as EWB-HU, have however, through their faculty advisors and the support of university administrations, been able to take teams of students on several service activities that have been combined with informal and formal

learning activities. In 2008, one group of students travelled to Senegal to construct and install a photovoltaic solar system in a previously non-electrified remote rural community under the guidance of two faculty members. A second team began a project with an underserved community in Bahia, Brazil, to help design, develop and construct a performance space for a community theatre group in a *favela* (slum). A third group travelled to the Nandi Hills community in the Choimim region of western Kenya, to assist a community based educational institution that supported both an orphanage for HIV-afflicted orphans and an elementary school improve their facilities. On these visits, service learning took place on a broad scale that was student driven and community based while being professionally mentored and academically advised.

These three projects provided sufficient educational and field experiences for the engineering student participants to become engaged in the community development process, beginning with problem selection, community interaction, project conceptualization, community feedback and engagement, responsiveness to community concerns, project design and eventually in project development and finally implementation. The challenge for the educator and the academic is to evaluate these projects and develop models for the institutionalization of such experiences so that the opportunity for participation is available to all students, not just those in a special membership based extra-curricular student organizations such as EWB-HU.

This paper begins with an exploration of teaching and learning and then seeks to utilize the experiences of the EWB-HU project teams to develop a model for an academic and curricular based service learning experience that can be incorporated into standard engineering curricula to provide all students in an engineering program with the benefit of these types of educational and practical experiences.

Teaching and Learning

We learn through our senses and our capacity to reason. We look, we hear, we touch, we feel, we taste and we bring whatever information, knowledge, and experience we have at the time to bear on that which we sense. That is how we process information. Different sorts of learning and teaching occur at different points and in different parts of our lives, and in different contexts. As newborns and infants, we learn through imitation and mimicry and our learning is, hopefully, guided and reinforced by the loving and caring hands and minds of our care providers and nurturer's. Because, without care and nurture, none of us would have learned, let alone learned to survive and prevail. This initial early learning is, by its very nature, random and chaotic. The flotsam and jetsam of information in the pre-school mind would most likely be unfathomable, confusing, and likely terrifying to any rational human or even an educational psychologist.

As we grow into our pre-school years, learning becomes differently organized, as does the teaching. Information begins to become categorized even as those very categories are being formed. Bits and pieces of data and random facts begin to align themselves into various structures; it seems like suddenly one is introduced to the idea of knowledge. Anybody who has been around children would be familiar with that transition from random data to connected information that has the beginnings of the patina of knowledge. In our pre-school years, learning happens in many ways – and rote recitation and straight memorization are important components of early elementary school pedagogy. The more enlightened of the pre-schools do incorporate sufficient free un-structured and protected learning typical, say, of a Montessori pre-school. There must also be experience and interaction and this must be connected to exploration and enquiry. But in many parts of the world, where half the world's children likely sit in a one-room schoolhouse or in a classroom under a tree, that element of

rote recitation and memorization has been a constant part of those children's learning, and will unfortunately be the only formal teaching they will have the opportunity to have.

The organization of the information, and the learning of that information, becomes more focused and disciplined as we move up the K–12 ladder. Science becomes chemistry, physics and biology; Arithmetic morphs hydra like into algebra, geometry, trig, and calculus; Social Studies becoming geography, US History, and World Religions; English and literature expand and multiply into a diverse spectrum of humanities courses. Once, we reach college, we are supposed to use all of what we learnt as the basic foundation upon which to build a specific disciplinary career. This broad exposure, if done right, will engender in the student the necessary understanding and appreciation for a diverse array of subjects that can form a strong foundation with depth and breadth, upon which disciplinary concentrations of study can be built. This is what differentiates *education* from *training*.

How we do that, grow those scientists, engineers, mathematicians, architects, psychologists, historians, sociologists and so on, is critical. It is important to examine our pedagogy and ensure the effectiveness of our teaching. This can only be done, if there is a continuous and rigorous evaluation and assessment of student learning. The standard university model of teaching of "chalk and talk" is no longer sufficient. University educators have long understood the weaknesses and insufficiency of the "chalk and talk" model. Our academic degree programs have progressed to now incorporate, at least in the better curricula, programs and schools, interactive learning as a core pedagogical tool. Here students participate in their own education, learning by asking questions and exploring issues interactively with a knowledge provider, whether that knowledge provider is a screen or professor. Our pedagogy has progressed even further. It is now routine to see, as part of every teacher's pedagogical repertoire, the problem-based or project-based learning exercise. Further, we know that when we place students in co-operative groups, learning is enhanced and students are more engaged and motivated, sensing the control they have over their own education.

Regularizing Service Learning

Service learning takes the problem-based and project-based educational model and develops and extends it further. SL takes learning outside the sterile confines of the classroom and moves it into the field and the community. Problem-based learning in the field can then occur in a real context. It is in this real context that group effort and team participation become important. It is in real world problems that the need for multidisciplinary solutions to complex global problems, in whatever field, becomes clearly evident and necessary.

It is important for our pedagogy to require our students to engage with their critical thinking and analytical skills, with quantitative rigor and scientific rationality, and with their disciplinary strengths and their team player skills, to work together in multidisciplinary teams, developing and implementing real solutions that address needs within communities across the globe.

Service learning is certainly not new. It has arguably been around since our rural forebears had their children doing chores to learn skills necessary to carry on society, ensuring the survival of the community. What this paper suggests is that the current educational paradigms and models need to be expanded to incorporate service based learning opportunities into regular academic curricula and programs that substantively and rigorously tie these experiences directly to regular degree program requirements.

An example of formalized service learning that has been around for a long time can be found in Cuba, specifically at the Cuban equivalent of MIT, known by its acronym, *CUJAE*. On a study tour to Cuba, lead by the

Howard University Project on Appropriate Technology in March 2003, students and faculty were exposed to curricula with a formal service-learning component. During this educational visit, three faculty and a group of fifteen students from Howard University participated in a study tour that included numerous site visits and meetings with individuals in government, education and the community. There, the students learnt that in the Institut Superior Polytechnica, Arcitectura, Y Ingineera/CUJAE, which is Cuba's equivalent of MIT, a senior design project is a requirement not unlike at MIT and almost all engineering programs. However, the big difference, is that the CUJAE senior project must be conducted outside the university in a community based setting and address a community problem, with the design project being the development and recommendation, with possible implementation, of a real solution.

The way the EWB chapters, both professional and campus based, initiate and develop projects is through a partnership between the chapter and a community that has an expressed need. Communities across the world seek assistance from EWB by posting or listing community needs or problems with the national organization. Chapters then seek out a problem from the listings that the Chapter's leadership and membership may have an interest in, and then partner with the community to develop a project that will address a specific need. The chapter works closely with the community and proposes possible solutions that the community reviews and evaluates, specifically to make sure that specific needs that the community has prioritized are being addressed. In the case of the EWB projects, partnerships are usually multi-year engagements that begin with an assessment visit and proceed from there through solution conceptualization, project design and development and end with implementation, all done through engagement, interaction and feedback with and from the community. A guiding imperative is the avoidance of top-down solutions and handouts, but engagement of the community in addressing their own needs and "buying-in" to the proposed solutions.

It is clear that it would extremely difficult to incorporate a multi-year team based project into the regular engineering curriculum. However, following the model that has been developed and implemented at *CUJAE,* final year design projects in engineering curricula can be moved in the direction of community-based problem selection. The entire EWB process, from project selection to solution development and implementation need not be required. The senior design project can be focused on community problem selection and then the development of proposals and models for solution. This truncated and abbreviated EWB project model can be the basis for enhancing current engineering curricula with real-world problems of critical environmental and social significance with sustainability as a core under-girding theme.

Educational Objectives and Outcomes

It is important to clearly articulate the educational objectives and expected educational outcomes from an institutionalized service learning component to any program's curriculum. Considering that, as per ABET (Accreditation Board of Engineering and Technology) guidelines and requirements, each accredited undergraduate degree program must clearly outline the programs educational objectives which must set about to meet the educational outcomes listed by ABET (a – k), as well as any specific additional educational outcomes, a particular program seeks to see in its students. Hence, at Howard University's department of Chemical Engineering, in addition to the standard educational outcomes as listed by ABET, we have added three others that the department faculty felt were unique to our program.

To institutionalize a service learning course within a degree granting program, the educational objectives for the SL course as well as the expected educational outcomes should both mesh into the programs educational objectives and outcomes. More specifically, if an SL course

is to be established as a required part of a program's curricula, the educational objectives and outcomes for the SL course would include those program objectives and outcomes that the course could be tailored to satisfy.

As a possible case study, it is helpful to consider a situation where the SL course is incorporated into, for instance, the senior design course. The senior design course is usually the capstone course for an undergraduate engineering program. If it is to be configured as an SL experience, the service learning capstone course should be a culminating experience that enables the students to integrate their learning from their total college experience, to make meaning of it, and to think how they can utilize it in the future (Jacoby, 2009). As a capstone engineering design experience, such an SL course must involve research with substantial service experience, followed by critical analysis and a final major written project report and oral presentation. Particularly for engineering capstone design courses, it would be important to ensure that the original senior design course's objectives and outcomes are maintained, although there are likely expanded outcomes from transforming the senior design course from a sterile industrial case study to a community-based service oriented course to be conducted half in the classroom and half in the field.

Independent Study Service Learning Courses

Several of the student participants in the EWB-HU assessment visits were interested in leveraging their service experiences into academic credit. The students were required to focus on an aspect of the EWB-HU service project and work with their faculty advisor and professional mentor to develop that area of focus into a course of critical study and reflection. The EWB-HU service project had a primary objective of increasing water quantity and quality in the rural community that were the target and partners of the project. Thus, one student focused on developing an independent course of study that would have the management, resourcing and treatment of water as the primary focus of the academic research and scholarly reflection, while a second student choose a broader and more education focused independent study project to develop an undergraduate general engineering elective course on appropriate technology.

The student who chose to focus on water, developed a broad understanding of water, examining the subject from various disciplinary perspectives, including environmental, engineering, political, social and economic approaches to the various aspects of the water resourcing, treatment, storage, distribution, and geopolitics. The final independent study project deliverable included an final technical report and oral presentation. The comprehensive technical report included sections on water quality, safe water standards, and technologies for water resourcing, extraction, storage and treatment. Social, political and economic aspects of water rights were covered as well.

The second student who chose the broader focus on education and appropriate technology devoted her independent study efforts to develop a curriculum for a one-semester course on Appropriate Technology for Developing Communities. The final report included course readings, a course syllabus, critical course content including introductory lecture presentations, complete course outline and a set of course expectations articulated as the deliverables for students taking the proposed course.

These examples of extending service experiences into exciting learning experiences that can be integrated into engineering course curricula are just the beginning. They need to be replicated and multiplied to leverage the commitment of young people to service and relate it closely to their educational requirements.

Conclusion

It is imperative that we move our pedagogy and more importantly our curricula, in this direction. One thing we know about our students is that most of them want to make a difference in their world, especially those in the millennial and following generations, be they generation X, Y or later. This is how, we can engage them and help them achieve that goal, contributing in the process, both to student development, community development, improvements in the quality of life, and enhancing the sustainability of communities as they seek to improve their standard of living

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