AC 2011-1324: THE EFELTS PROJECT - ENGINEERING FACULTY ENGAGEMENT IN LEARNING THROUGH SERVICE

Christopher W. Swan, Tufts University

Chris Swan is an associate professor of Civil and Environmental Engineering with additional appointments in the Jonathan M. Tisch College of Citizenship and Public Service and the Center for Engineering Education and Outreach at Tufts University. Dr. Swan has also served as chair of Tufts CEE department (2002-2007) and as an officer in the Environmental Engineering division of ASEE (2001-2005). Dr. Swan's current interests lie in the areas of waste reuse, and service-based educational efforts in the engineering curriculum. Specific efforts involving engineering education concern project-based learning and service-based pedagogies their potential impacts on student learning and how these impacts may be evaluated and assessed.

John J. Duffy, University of Massachusetts Lowell

Professor, Faculty Coordinator of Service-Learning

Kurt Paterson, Michigan Technological University

Kurt Paterson is on the environmental engineering faculty, where he currently serves as Director of Michigan Tech's D80 Center (www.d80.mtu.edu), a consortium of 20 research, education, and service programs dedicated to creating appropriate solutions with the poorest 80% of humanity. His research, teaching and service interests focus on appropriate technology solutions that improve public health, international project-based service learning, and engineering education reform. Prof. Paterson teaches courses on creativity, engineering with developing communities, and community-inspired innovation. He has served the American Society for Engineering Education in numerous capacities, as a member of the International Strategic Planning Task Force, the International Advisory Committee, and Global Task Force, and as Chair of the International Division. He actively serves Engineers Without Borders-USA, as a chapter co-advisor, education committee chair, and lead on EWB's efforts to examine its educational impacts. He is currently leading several NSF-funded projects involving the design and assessment of service learning in engineering education. He is co-author of several recently released books, including: Measuring the Impacts of Project-Based Service Learning on Engineering Education, Engineering in Developing Communities: Water, Sanitation, and Indoor Air, and Environmental Engineering: Fundamentals, Sustainability, and Design.

Dr. Angela R Bielefeldt, University of Colorado, Boulder

Angela Bielefeldt, PhD, PE, is an Associate Professor in the Department of Civil, Environmental, & Architectural Engineering at the University of Colorado at Boulder (CU). She began involvement with service learning (SL) in 2001, when she began integrating SL into the senior capstone Environmental Engineering Design course. Her research interests include ceramic water filters for household drinking water treatment in developing communities, bioremediation, and engineering education.

Olga Pierrakos, James Madison University

OLGA PIERRAKOS is an assistant professor in the new School of Engineering, which welcomed it inaugural class August 2008, at James Madison University. Dr. Pierrakos holds a B.S. in Engineering Science and Mechanics, an M.S. in Engineering Mechanics, and a Ph.D. in Biomedical Engineering from Virginia Tech. Her interests in engineering education research center around recruitment and retention, understanding engineering students through the lens of identity theory (NSF BRIGE grant), advancing problem based learning methodologies (NSF CCLI grant), assessing student learning, as well as understanding and integrating complex problem solving in undergraduate engineering education (NSF CAREER grant). Her other research interests lie in cardiovascular fluid mechanics, sustainability research, and K-12 engineering outreach.

The EFELTS Project - Engineering Faculty Engagement in Learning Through Service

Abstract

This paper outlines the development of a three-year effort that focuses on *Learning Through Service* (LTS) – a pedagogical method that combines academic learning with service. EFELTS involves investigators from Tufts University, James Madison University, Michigan Technological University, the University of Colorado Boulder, and the University of Massachusetts Lowell. These five, diverse institutions (public and private, small and large, etc.) will invoke a 4D Process (Discover, Distill, Design, and Disseminate) to realize two project goals: a) evaluate the impacts on faculty currently engaged in LTS efforts; and b) empower additional faculty to implement LTS.

Major activities to be undertaken during the EFELTS effort include: a) surveying and interviewing engaged faculty; b) convening meetings of "experts" in LTS program/course designs, implementations, and assessments; c) conducting intensive faculty training workshops on LTS that lead to new LTS efforts at course and program levels; and d) sustaining faculty engagement via a continued dissemination of efforts. Assessment research methodologies (development and use) are integrated throughout these activities.

Expectations from the effort range from engaging faculty to implement and support LTS in engineering education to expanding the list of appropriate teaching, learning and assessment methodologies that are appropriate and enhance engineering education. The EFELTS effort is also expected to:

- Expand the use of LTS in engineering education AND highlight LTS as a viable research endeavor and scholarly activity;
- Explore the synergy and differences between curricular and extracurricular service activities in engineering education;
- Identify challenges and facilitators to LTS for different faculty and institution types;
- Place an importance on pedagogy in the development of future engineering faculty;
- Create service-minded engineers who assist communities-in-need through engineering; and
- Study whether service is, and should be, an accepted part of the engineering profession.

1. Introduction

Engineering education has conventionally focused on developing students' technical skills. Over the last few years, concerns have escalated among many national organizations that technical expertise solely is no longer sufficient.[1,3,4,36] Engineering education must be restructured to adequately prepare engineers for the anticipated future challenges of globalization, sustainability, complexity, and adaptability. Additionally, in the United States engineering programs continue to struggle to attract students, especially women and minorities. The need for a "paradigm shift" is recognized, but there is not always substantial research to support proposed changes. Learning Through Service (LTS) seems to hold great promise in meeting some of these future challenges, though there is a need for continued research.

There is evidence to suggest that engineering programs which emphasize humanitarian efforts and service to society attract many students, notably women.[11] An interesting development has been the largely student-led growth of Engineers Without Borders-USA (EWB). Nearly 190 university chapters were started within seven years of the organization's inception (more than half of the nation's engineering colleges have a chapter); this phenomena is unprecedented in that it occurred outside the influence of academia or government, and has fueled the creation of similarly-focused curricular programs at many universities.[40] Most chapters report similar observational findings: highly motivated students finding a professional passion, of which virtually half are women. With this backdrop, and as characterized in Figure 1, engineering faculty are under pressure to deliver this shift; but are they prepared?

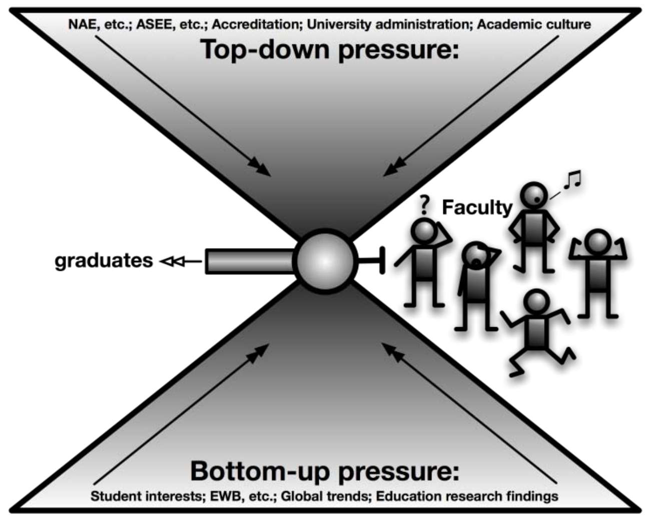

Figure 1. Faculty, under pressure from all sides, are the valve operators for producing the graduates needed to address requirements of many higher education

An issue of concern with including service efforts by engineering students in engineering education is that little is known about the impacts of such efforts. While some university-level assessments have been conducted,[20, 38] coordinated, multi-institution, long-term assessment efforts are just beginning to examine outcomes for all stakeholders (e.g. students, faculty, institutions, and partners). This includes LTS impacts on the ABET Criterion 3a-k learning outcomes, students' self-efficacy, identity, motivation and attitudes towards learning. Therefore, the connected research question is: Does LTS provide an avenue for the paradigm shift desired by national leaders and students alike?

Engineering faculty development in LTS should be an outcome to foundational research on whether LTS is effective in supporting the paradigm shift in engineering education needed to meet future challenges. This proposal is focused on both 1) adding to the research-based understanding of the ways in which LTS can contribute toward this needed paradigm shift and 2) providing a sustainable process to develop faculty who will understand and most effectively practice LTS methodologies in their teaching. Various elements will be used in the proposed effort for research and faculty engagement.

2. Motivation

Learning Through Service (LTS) is an amalgamation of various pedagogical methods, including service-learning which is often (mis)used to describe these various pedagogical methods. The distinguishing factor of LTS is the intentional design to incorporate service as a means to meet academic learning objectives. Additionally, the project-based element, connected to a community's need, provides the socio-cultural context, stimulating the process of collaborative problem solving. When the complementary pedagogies (project-based and service-based learning) merge, there is potential for student development on cognitive [16, 17, 28, 41, 45], social [18, 23, [47, 48], and moral [15, 31, 29] levels; these three developmental processes that can often trigger each other or occur simultaneously. These developmental/cognitive constructs, based on the theories of Dewey, Piaget, Kohlberg, Vygotsky, and Kolb[16,17,31, 32, 41, 47, 48], become evident in LTS experiences, ultimately leading to maturation, heightened self-awareness, and greater complexity in cognitive reasoning and development.

Kolb further identified strategies to increasing retention of knowledge in students. According to his theory, learning must begin with motivation, upon which theory, application, and analysis are founded. Engineers Without Borders, like many other service programs, is completely voluntary; the motivation to help others and to learn is instilled within those who join.[39] The service aspect of LTS efforts initially motivates students to participate, but the cycle of overcoming problems and continual learning nourishes them. Regardless of the construct, each suggests that LTS should offer a rich learning environment for engineering students; one that fosters not only their cognitive development, but provides strong opportunities for professional development.

Student interest in curricular and extracurricular LTS efforts has created institutional momentum for integrating the approach within engineering curricula. LTS has been incorporated into first-year project courses, core engineering science courses, and senior design courses.[6, 24, 38, 42, 46] Previous research has shown many beneficial student outcomes from well-designed LTS efforts and programs (Table 1).

However, numerous challenges with LTS projects have been identified [2, 10, 27] including: 1) a need for the project purpose to align with program outcomes, a challenge when communities are equal partners in the process; 2) a meaningful relationship with the community is imperative, particularly an on-going relationship to ensure that the community goals are served; 3) a project planning phase before the beginning of the course is more critical to ensure a successful project; 4) site visits are very helpful so that students feel a connection, but this can be difficult if class sizes are large or when working on international projects; and 5) a number of implementation challenges must be considered in project delivery including regulations, liability, local constraints, and sustainability.

As noted, extracurricular LTS efforts have grown especially rapidly, perhaps due to the comparative lack of academic administrative hurdles. As the agents of university culture, though, the faculty must accept responsibility for the much slower adoption of LTS (and other high-potential pedagogies) into engineering curricula. This project aims to provide the motivation, training, and resources to catalyze widespread adoption of LTS among engineering faculty, departments, and colleges interested in offering modern and effective curricula.

3. Project Methodology

Our effort consists of two main goals:

- *Goal 1:* Understand the motivations, obstacles, and strategies for engineering faculty who currently offer LTS opportunities
- *Goal 2:* Increase the involvement of engineering faculty engaged in LTS

Table 1. Potential Student Outcomes from Curricular and Extracurricular LTS Efforts

Desired Student Outcome	**LTS Benefits and Examples**
Design a system or process within realistic constraints such as economic, environmental, social, political, ... [ABET[1]]	Greater complexity and range of constraints in LTS settings deepened these abilities among students in capstone design courses [7,8]
Cultural competency	Developed as students work to understand the needs of communities with different cultural backgrounds from their own, both subtle or significant[9]; international community service experience beneficial in MTU D80 program [38,39]
Understand the impact of engineering solutions in a global and societal context [ABET[1]]	Enhanced by working directly with a community [19,20,35,43]; >95% of students engaged in a LTS capstone design experience self-reported high awareness of the social impact of engineering, significantly higher than non-LTS project participants[33]
Understanding professional and ethical responsibility [ABET[1]]	Enhanced on LTS projects, even if not a central theme of the project [10,20,35,43]
Attitudes toward community service (CS)	Higher CS scores for EWB participants and high for students in Engineering for Developing World course [9]
Self-efficacy, self-confidence, self-esteem	Confidence in own abilities is enhanced, particularly as students achieve success and see the true benefits to a community [26]
Critical thinking / scientific reasoning	Critical thinking gains demonstrated for LTS outside engineering [5,44]
Engineering identity	Redefine engineering as a helping profession particularly effective in first-year projects courses
Ability to communicate effectively [ABET[1]]	Students required to communicate with community members who are often non-technical and across language and cultural differences [7]
Function on multidisciplinary teams [ABET[1]]	Greater stresses on LTS projects may force students to learn better interaction skills; many LTS projects are more multi-disciplinary, including non-engineers[35]
Recognize need for and ability to engage in lifelong learning [ABET[1]]	Because PBSL projects are often less structured and can go in many directions, students commonly forced to a just-in-time learning model
Sustainability; Analyze systems of engineered works for sustainable performance	Length of time working with communities on service learning projects directly influences usage and diversity of sustainability concepts [39]; evident in reflective essays from students in senior design who worked on LTS projects[7]
Leadership [ASCE BOK[3]]	Students' have stronger understanding of leadership and skills to motivate others to achieve a common vision [19,21,35]
Creativity; *Creative Design*	Open ended nature of many LTS projects with vast array of non-technical and technical constraints forces students to be creative to find best solutions for communities[13]

3. Project Methodology

Our on-going effort consists of two main goals:

- *Goal 1:* Understand the motivations, obstacles, and strategies for engineering faculty who currently offer LTS opportunities

- *Goal 2:* Increase the involvement of engineering faculty engaged in LTS

For the EFELTS project, each goal is divided into a set of objectives that, if met, will provide measurable outcomes. For Goal 1, the two objectives are: a) understanding *why* faculty adopt LTS and b) understanding *how* faculty implement LTS. Expected outcomes for our project, to meet these objectives, are to provide (1) a nationwide picture of faculty involvement in LTS, (2) insight into any institutional differences in LTS implementation, (3) knowledge of curricular/extracurricular LTS approaches used by faculty, (4) insight into community partner/employer impacts, and (5) an understanding of persistence issues. Efforts will also identify professional and personal benefits of LTS as well as costs, such as tradeoffs made to other faculty responsibilities. Together this will provide evidence-based guidance from a diverse range of engineering faculty, which can better assist others in making informed choices.

For Goal 2, the three objectives are to: a) provide an insight on the level of faculty involvement in LTS; b) promote widespread implementation of LTS in engineering education, and c) create faculty resources needed to lower barriers for participation while developing faculty expertise in LTS. The outcomes from these efforts will include: (1) faculty resources for development, management, and assessment of LTS programs; (2) faculty/staff resources for training other faculty in LTS; (3) summary reports/presentations for administrators, industry, and community partners; (4) publication of successful programs; and (5) a nationwide picture of faculty and institutional transformations.

To achieve these goals, our methodology aims to develop a tipping point in engineering education with the 4D Process (Discover, Distill, Design, and Disseminate). The *Discover*y stage involves reviewing previous LTS efforts through the examination of LTS engineering faculty leaders and learning from their histories in LTS design and implementation. The *Distill* stage evaluates these surveys/interviews to uncover common patterns and elements. The wisdom captured in the Distill stage will serve as the basis of materials created for workshops and webinars - the *Design* stage. The process proceeds to spreading the best practices and expert advice through designed resources - the *Disseminate* stage. It is hoped that through these efforts, critical mass (an LTS nuclei) at institutions will be created, as well as key LTS champions, together capable of education reform (i.e., paradigm shift) at their institution and beyond. The 4D Process uses continuous assessment to measure and inform project at all stages.

3.1 Process Components

Project components, and the measurable outcomes to meet our projects goals and objectives, are briefly detailed below.

3.1.1 Discovery: Surveys

Faculty surveys will be adapted by the EFELTS collaborative based on those developed, tested, and implemented in the SLICE program at the University of Massachusetts Lowell (UML).[12] These surveys will be used to track the integration of LTS into programs and courses by faculty at participating institutions. Surveys will be distributed once a year, and will be supplemented by a limited number of faculty interviews (see Section 3.1.2). The survey requires faculty responses on a Likert scale of 1-9 (strongly disagree to strongly agree) to a series of statements such as: "I agree in principle with the goal of having at least one service-based effort available every semester for students in our college." At least 100 responses are planned over the project's duration with distribution (and responses) expected from a range of faculty (junior to senior, tenured/tenure-track vs non-tenure-track, etc.) from various engineering disciplines and institutions (public vs private, small vs large, undergraduate vs graduate foci, etc.). Participant recruitment will be done via electronic means; e.g., solicitations via department head listservs, engineering associations and professional society listservs, and research and education groups and affiliations. Surveys will inquire about and track changes in faculty perspectives and attitudes in regards to LTS integration at their institution, as well as their underlying pedagogical philosophy and training. Differences in faculty LTS adoption experiences will also be explored in order to compare, contrast, and analyze outcomes, impacts, and potential best practices of LTS. The survey will measure and track motivations, barriers, and professional impacts. Faculty responses will form an important part of the research into the outcomes of LTS achieved through various models.

3.1.2 Distill: Faculty Interviews

Qualitative data will be obtained through in-depth interviews of faculty. Over a three-year period, a total of 75 faculty interviews will be conducted – 20 during Year 1, 25 during Year 2, and 30 during Year 3. Year 1 interviewees will be LTS leaders and faculty with considerable experience. Years 2 and 3 will include leaders as well as new LTS faculty developed through this project. Annual faculty interviews provide both formative and summative assessments of LTS adoption and integration. Previous faculty interview efforts, conducted at UML over the last five years, provide a basis for the EFELTS team to review and tailor interview questions in ways that address objectives of this initiative. In general, faculty interview questions will inquire about pedagogical philosophy, teacher training and methods, LTS integration approaches, lessons learned, and suggested best practices. Interview data will supplement data gathered through the faculty survey (see Section 3.1.1 above).

In addition to continuous interviews, post-LTS implementation interviews and debriefings will be conducted to document the process of LTS integration at various institutions across the nation. Post-implementation interviews will provide faculty with an opportunity to reflect upon and share their experiences. In addition, this information will provide periodic monitoring that will describe how LTS integration evolves, or does not, within various academic environments and conditions. Continuous interviews during a faculty's LTS implementation effort will provide information useful for sustaining each participant's efforts at their respective institutions.

3.1.3 Design: Expert Group Meeting

A meeting of LTS "experts" will be convened as part of the Design stage of the 4D Process. The meeting will involve those experienced in LTS development, assessment, implementation, and research, both from engineering and non-engineering disciplines. Run more as focus groups to gather information, the three major themes of the effort include the Design, Management, and Assessment of LTS (see Table 2); themes that will serve as the foci of the workshops for faculty new to LTS (see Section 3.1.4). Specifically, the intended outcome of the LTS Design conversation will help faculty create an effective learning experience for students and beneficial projects for community partners. For Management, the conversation will center on establishing an effective, efficient, and sustainable course/program. LTS Assessment will gather feedback on how to best convert experiences into meaningful and useful information that will strengthen the acceptability of LTS in engineering education. Findings from the LTS expert meeting, combined with research and experiences of the EFELTS team, will serve as the basis of LTS Workshops and materials to transmit knowledge, skills, and attitudes for success to a new cadre of LTS faculty.

The meeting will include 10 to 15 invited experts. These experts will be identified via their peer-reviewed publications, presentations at conferences (EPICS, EWB, ASEE, FIE, National Service-Learning Conference, etc.), and general profile in the field. Some individuals have expertise in more than one area, in which case they will be invited to select the topic to which they wish to contribute. The goal will be to include experts across multiple disciplines in engineering, and multiple forms of service integration (into first-year project courses; senior design courses; as units in required core technical courses; as extracurricular activities; into local and international communities). Potential participants include faculty and staff at service-focused academic centers such as Purdue's EPICS program, the University of Michigan's ProCEED, the University of North Carolina at Chapel Hill's APPLES program, and the University of Dayton's ETHOS program.

Table 2. Themes and topics of Expert Group Meetings (and Subsequent Workshops)

Themes	***LTS Design***	***LTS Management***	***LTS Assessment***
Topics	• learning objectives • pedagogical support • course and program models • design for easier management (or "design for the overloaded professor") • design for effective outcomes analysis	• recruiting students, colleagues, and community partners • getting administrative support • strategies for effective implementation • handling unplanned events • promoting efforts internally • sharing work externally	• why assess? • setting assessment goals • putting together an assessment strategy • building an assessment team • assessing students • assessing faculty • assessing university • assessing community

3.1.4 Disseminate: LTS Workshops

Three faculty development workshops (LTS Faculty Fellows Workshops) are scheduled in Year 3 of the effort. One workshop each will be held in the western (Colorado), midwest (Michigan), and eastern (Massachusetts) parts of the country. These professional development opportunities will be based on a model of faculty development that has proven successful: voluntary yet by recommendation of department chairs and deans, adapted to and formed by the learning objectives of the participants, and collegial in style. The workshops will be divided into three parts: 1) a discussion around LTS design, management, and assessment, led by the workshop facilitators; 2) application of LTS (e.g., an active learning experience); and 3) connection to the

LTS community for continued direction and input. The number of workshop participants will be limited to 15 to allow for more thorough and in-depth discussion and exploration of the topics, and for optimal sharing of ideas. For the proposed workshops, individuals must apply with selection based on their plan to include LTS efforts in their teaching. In addition, faculty will be strongly encouraged to attend with one or two colleagues from the same institution to create an institutional LTS nucleus.

Whereas the workshops serve as an effective means for refining engineering faculty training, they become resource constrained. Therefore, though not a funded part of the effort, all workshops will be videotaped with the purpose of capturing critical footage to be compiled into a series of concise lessons available for on-demand viewing through the project website. Based on research findings into podcasting for engineering education[37], these webinars will be structured lessons with clear learning goals, suggested reading, a podcast (15 minutes maximum), and recommended next steps. The overall EFELTS effort will not reach full impact without multiplying the training of trainers. One frequent comment heard during the NSF-sponsored project "Assessing the Impacts of Project-Based Service Learning on Engineering Education" was the need for LTS resources not only for newly interested faculty but also for faculty or staff who are interested in catalyzing LTS at their institutions by training others.[40] To this end, all workshop materials and a workshop best practices guidebook.

3.2 Project Assessment Plan

3.2.1 EFELTS Evaluation

The project's evaluation plan will utilize both formative and summative evaluations, combining the use of quantitative and qualitative methods with direct and indirect assessment measures. This triangulation, mixed-method approach will enable in-depth analyses of the program to evaluate the conclusions of processes and outcomes.[22, 34, 49] The outcome evaluation will produce information primarily designed to measure the effects or results of the program[30], while the process evaluation will take into account not only how the program produces its effects, but also what parameters influence its effectiveness.

The evaluation plan will also include input from an External Advisory Board (EAB). For example, the formative evaluation results will assist in framing the features and services that the project offers, and the EAB will utilize the feedback to make curricular and programmatic changes (e.g. in the workshops, 'best practice' manuals, etc.) that better align produced resources with participant needs. The EAB will meet twice annually for the duration of the grant, once per year in person (a meeting to be held before/after the annual ASEE Annual Conference and Exposition) and once per year as a web-conference.

Summative evaluation results will provide accountability measures with regard to the project's effectiveness in achieving its goals as well as its overall impact. The three main questions that will be addressed in these regular evaluations will be: (1) To what extent and in what ways is the project management team achieving its program goals? (2) To what extent and in what ways are program participants satisfied with and perceive benefit from their experience? (we plan to administer surveys of faculty who have participated in each project element and use that input to make improvements in the element), and (3) How effective are the individual elements in each phase of the project (research methods and tools in the first phase, design and delivery of workshops in the next phase, etc.) in supporting the project's goals? Where are revision and improvement possible?

Participants' reactions to, reflections of, and participation in the various educational events will be captured through survey instruments and focus groups to evaluate the degree to which progress is being made toward creating a LTS community of scholars and practitioners in engineering. Participant satisfaction with, and perceived benefit from, both the overall program and the individual components will be collected from a multitude of sources, allowing for the triangulation of data across project participants and elements.

In addition, web analytics will be conducted to assess the extent and nature of web traffic generated on the project website. We will also measure, through tracking, the degree of extension of project elements to individuals and institutions beyond the initial core schools. The evaluation results will be used to support decision-making throughout the process and guide the development of a long-term, sustainable model for fostering the support of effective learning through service in engineering. Results will be disseminated via interim reports to facilitate refinement and final reports to show results and demonstrate accountability.

3.2.2 LTS Implementation Evaluation

As noted in Section 1, a major weakness of previous LTS efforts is the lack of formal assessment. Even when assessment is formally planned, it often does not align well with the objectives of the LTS experience. LTS thus requires well-grounded outcomes-based assessment methodologies. Our assessment efforts will center around two stakeholders of LTS – faculty and students.[25]

A mixed-methods approach is appropriate for this study because triangulation enables us to neutralize the disadvantages inherent in all types of methods, and different methods are needed to understand the complexities of social phenomenon.[14] Qualitative methods, such as journal entries, rubrics, interviews/focus groups, and questionnaires will provide data that enhance quantitative instruments such as surveys. The qualitative data will be transformed in the analysis phase into quantitative terms that enable the integration of both sources of information. This approach, concurrent triangulation design, is a mixed-methods design in which researchers collect and compare both qualitative and quantitative data in a single study.[14]

Aligned with project goal #1, the assessment efforts will involve measuring the impacts of LTS on faculty. Typical assessments centered around faculty will measure the impacts and lessons learned during LTS implementation, management, and assessment (for varying types of LTS experiences, course levels, institutional cultures, program characteristics, disciplinary settings, community partner characteristics, student characteristics, etc.). Aligned with project goal #2, the assessment efforts will involve measuring how LTS impacts student learning and how faculty can use assessments to increase and enhance implementation of LTS efforts. Typical assessments centered on students include measures of (a) student motivation and engagement, (b) self-efficacy, (c) student perceptions and learning outcomes during different types of LTS experiences, etc. Findings from these assessment efforts will enable the EFELT team to develop a framework that can be disseminated to faculty on the development, implementation, and assessment of LTS experiences to meet the needs of a community partner, a program, a course, a project, and to begin to change the culture, etc.

Other assessment/evaluation factors to be considered include institutional and community impacts. However, our focus will not be on what these impacts are for these stakeholders as much as how they affect faculty engaged in LTS. Thus, our faculty surveys and interviews will serve to collect basic information from LTS implementations that relate to their campuses (number of students, disciplines, type of course/program, positive and negative consequences, etc.) as well as their community partners (number and types of projects, number of community members served, positive and negative consequences, etc.).

Both project evaluation and LTS implementation assessment results will be analyzed by the external evaluator who, in consultation with project personnel, will work to identify, adopt or adapt the appropriate instruments used in developing answers to the research questions. We will use previously field-tested and validated instruments whenever possible, and for LTS implementation assessments we will use comparison groups as controls to allow us to draw conclusions from our data. For example, the external evaluator will use developed data to conduct an investigation into the LTS implementation's effectiveness by examining both within-groups and between-groups effects, further identifying through factor and regression analyses those variables of participants and projects most predictive of measured effects.

4. Broader Impacts - Project Significance and Impact

This project has the potential to shape engineering education in many beneficial ways; providing a unique opportunity for 1) a longitudinal study to track and learn through faculty professional development focused on LTS, 2) a knowledge base useful to educators, and 3) directions of future educational program development. Sampling such a large number of faculty and their educational institutions can add significantly to our knowledge of faculty development based on a compelling, empowering approach to education.

4.1 Community Building

With existing LTS-involved faculty scattered across many institutions, often championing LTS in isolation, a formal LTS faculty community is long overdue. ASEE has recently approved a Service in Engineering Education (SEE) Constituent Committee, the first step in progressing to a formal Division. This Division will provide a venue for faculty from many disciplines to learn from one another in focused sessions of mutual interest, rather than being lost amongst many Divisions, often as add-ons to potpourri sessions. Because of this momentum, it is anticipated that an SEE Division will be in place within ASEE by Year 3 of this grant. This face-to-face opportunity will catalyze further development of LTS efforts in engineering education.

4.2 Program Sustainability

Like any development project, sustainability is rooted in capacity building that is resource appropriate and culturally focused. In this case, the project provides three years to catalyze the creation of much-needed resources: expert wisdom made available to all, easy-to-use and effective tools, and learning communities both real and virtual. Knowledge, skills, attitudes and identity embody all cultures; and this project will assemble those most needed for an LTS culture to flourish within engineering education. Once established, the LTS faculty community will expand the effort through collaborative research proposals, publications, presentations, and ultimately, refined curricular models. As curricular exemplars accumulate successes, sharing outcomes at all levels (e.g. Engineering Deans' Institute, NAE, student conferences, etc.) will further feed the interest in crafting LTS activity within engineering programs.

4.3 Measureable Outcomes

Many of the measureable outcomes are discussed in Section 3 above. Some of the key metrics to be measured in this effort include:

- Number and type of faculty as LTS students (for workshops, webinars)
- Number and type of faculty as LTS trainers (for local workshops)
- Courses/programs developed (numbers, models)
- Faculty engaged in LTS development or administration (numbers, ranks, disciplines, gender, institution as obtained through surveys and virtual and real communities)
- Number and type of student engaged in LTS
- LTS career impacts to faculty
- Learning outcomes for students from participation in LTS activities
- Institutions with LTS (program models, number of faculty and students involved, disciplines)
- Communities benefited by LTS (locations, number of projects created, project types, number of people affected)

5.0 Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant Nos. 1022927, 1022883, 1022738, 1023022, and 1022831. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

6.0 References

1. ABET (2008). *Criteria for Accrediting Engineering Programs Effective for Evaluations During the 2009-2010 Accreditation Cycle*, 21 pp., ABET Engineering Accreditation Commission. www.abet.org
2. Aidoo, J., J. Hanson, K. Sutterer, R. Joughtalen, and S. Ahiamadi (2007). International senior design projects – more lessons learned, *National Capstone Design Course Conference Proceedings*, Paper 11810. Boulder, CO.
3. American Society for Civil Engineering (ASCE) (2008). *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*, 2nd Edition, 191 pp., ASCE. www.asce.org.

4. American Academy of Environmental Engineers (AAEE) (2009). *Environmental Engineering Body of Knowledge*., AAEE, 91 pp. www.cecs.ucf.edu/bok/publications.htm
5. Astin, A.W., L. J. Vogelgesang, E. K. Ikeda and J. A. Yee (2000). *How Service Learning Affects Students*, Higher Education Research Institute, University of California – Los Angeles.
6. Bielefeldt, A.R. (2005). Challenges and rewards of on-campus projects in capstone design, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Design in Engineering Education Division. Portland, OR.
7. Bielefeldt, A.R. (2007a). Environmental engineering service learning projects for developing communities, *National Capstone Design Course Conference Proceedings*, Paper 12183, June 10-12, University of Colorado – Boulder, CO.
8. Bielefeldt, A.R. (2007b). Engineering for the Developing World Course Gives Students International Experience, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*. Paper AC 2007-799.
9. Bielefeldt, A.R. (2008) Cultural competency assessment, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Paper 2008-2313, June 23-25, Pittsburgh, PA (2008).
10. Bielefeldt, A.R., K. Paterson and C. Swan (2009). *The State of Project-Based Service Learning in Engineering Education*. NSF Report. 25 pp.
11. Bielefeldt, A.R., K.G. Paterson, and C.W. Swan (2010). Measuring the Value Added from Service Learning in Project-Based Engineering Education. *International Journal of Engineering Education. In press for Special Issue on Problem-Based Learning*, Accepted for 26(2).
12. Burack, C., J. Duffy, A, Melchior, and E. Morgan (2008). Engineering Faculty Attitudes Toward Service-Learning. ASEE Annual Conference. Paper AC 2008-1521
13. Christy, A.D. and M. Lima (2007). Developing creativity and multidisciplinary approaches in teaching engineering problem solving, *International Journal of Engineering Education*, 23, 4, 636-644.
14. Creswell J.W. (2003). *Research Design-Qualitative, Quantitative, and Mixed Methods Approaches*, 2nd Ed., London: Sage Publications.
15. DeVries, R. and L. Kohlberg (1987). *Constructivist early education: Overview and comparison with other programs*. Washington, D.C: National Association for the Education of Young Children.
16. Dewey, J. (1916). *Democracy and Education*, Free Press, New York .
17. Dewey, J. (1938). *Experience and Education*, Collier Books, New York .
18. Duckworth, E. (1996). Either we're too early and they can't learn it, or we're too late and they know it already: The dilemma of 'applying Piaget', in *The having of wonderful ideas and other essays on teaching and learning*, 2nd. Ed., Teachers College Press, New York, pp. 31-49.
19. Duffy, J., D. Kazmer, L. Barrington, J. Ting, C. Barry, X. Zhang, D. Clark and A. Rux (2007). Service-learning integrated into existing core courses throughout a college of engineering, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Paper 2007-2639, 34 pp.
20. Duffy, J., W. Moeller, D. Kazmer, V. Crespo, L. Barrington, C. Barry and C. West (2008). Service-learning projects in core undergraduate engineering courses, *International Journal for Service Learning in Engineering*, 3, 2, 18-41.
21. Ejiwale, J. and D. Posey (2008). Enhancing leadership skills through service learning, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Paper 2008-2457.
22. Fraenkel, J.R., and Wallen, N.E. (2006). How to Design and Evaluate Research in Education, (6th Ed.). McGraw-Hill, New York, NY.
23. Felder, R.M. and R. Brent (2004). The intellectual development of science and engineering students. 2. Teaching to Promote Growth, *Journal of Engineering Education*, 93(4): 279-291.
24. Fuchs, V.J. (2007). *International engineering education assessed with the sustainable futures model*, MS Thesis, Michigan Technological University, Houghton, MI, USA, 60 pp.
25. Gelmon, S.B., B.A. Holland, A. Driscoll, A. Spring, and S. Kerrigan (2001). *Assessing service-learning and civic engagement*. Campus Compact.154 pp.
26. Gokhale, S. and M. O'Dea (2000). Effectiveness of community service in enhancing student learning and development, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, St. Louis, MO, June, Session 1621.
27. Hanson, J.H., R. J. Houghtalen, J. Houghtalen, Z. Johnson, M. Lovell and M. Van Houten (2006). Our first experience with international senior design projects – lessons learned, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, June 18-21, Chicago, IL.

28. Harrisberger, L., R. Heydinger, J. Seeley and M. Talburtt (1976). *Experiential Learning in Engineering Education, Project Report*, American Society for Engineering Education, Washington, D.C.
29. Jaccoby, B. and Associates (1997). *Service-learning in Higher Education*, Jossey-Boss, San Francisco, CA.
30. Kellaghan, T. and Madaus, G. F. (2000). Outcome evaluation. In D. F. Stufflebeam, G. F. Madaus, & T. Kellaghan (Eds.), Evaluation models: Viewpoints on educational and human services evaluation (2nd ed). Boston: Kluwer Academic. pp. 97-112
31. Kohlberg, L. (1975). The cognitive development approach to moral education, *Phi Delta Kappan*, 56, 670-677.
32. Kolb, D.A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall, Englewood Cliffs, N.J.
33. Kremer, G. and D. Burnette (2008). Using performance reviews in capstone design courses for development and assessment of professional skills, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Paper 2008-1041, in presentation slides (2008). http://www.ent.ohiou.edu/~me470/Resources/ASEE2008_ presentation_PerformanceReviews.ppt
34. Mark, M., Henry, G. T. and Julnes, G. (1999). Toward an Integrative Framework for Evaluation Practice. The American Journal of Evaluation, 1999, Vol 20, pp. 177-198.
35. McCormick, M., C. Swan and D. Matson (2008). Reading between the lines: evaluating self-assessments of skills acquired during an international service-learning projects, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Pittsburgh, PA.
36. National Academy of Engineering (NAE) (2004). *The Engineer of 2020: Visions of Engineering in the New Century*, Washington, D.C.: National Academies Press, 118 pp.
37. Paterson, K.G. (2007). Podcast-Enhanced Learning in Environmental Engineering, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*. Honolulu, HI. AC2007-1012, 12 pp.
38. Paterson, K.G. (2008). Development for the other 80%: assessing program outcomes. *Global Colloquium on Engineering Education Proceedings*, Cape Town, South Africa.
39. Paterson, K.G. and V.J. Fuchs (2008). Development for the other 80%: engineering hope, *Journal for Australasian Engineering Education*, 14(1): 1-12.
40. Paterson, K.G., A.R. Bielefeldt, and C.W. Swan (2009). An online community for project-based service learning, www.d80.mtu.edu/PBSL
41. Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures*, Viking Press, New York.
42. Piket-May, M.J., J. P. Avery and L. E. Carlson (1995). 1st year engineering projects: a multidisciplinary, hands-on introduction to engineering through a community/university collaboration in assistive technology, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Session 3253, pp. 2363-2365.
43. Pritchard, M.S. and E. Tsang (2000). Service learning: A positive approach to teaching engineering ethics and social impact of technology, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, Session 3630.
44. Sedlak, C.A., M. O. Doheny, N. Panthofer and E. Anaya (2003). Critical thinking in students' service-learning experiences, *College Teaching*, 51(3): 99-103.
45. Siegler, R. (1991). Piaget's Theory on Development, In *Children's Thinking*, Prentice Hall, Englewood Cliffs, NJ, pp. 21-61.
46. Swan, C., T. Rachell, and K. Sakaguchi (2000). Community-based, service learning approach to teaching site remediation design, *American Society for Engineering Education (ASEE) Conference and Exposition Proceedings*, June, St. Louis, MO.
47. Vygotsky, L.S. (1978). Interaction between learning and development, in L.S. Vygotsky, *Mind and Society: The development of higher psychological processes*, Harvard University Press, Cambridge, MA, pp 70-91.
48. Vygotsky, L.S. (1986). The development of scientific concepts in childhood, in L.S. Vygotsky, *Thought and Language*. MIT Press, Cambridge, MA, pp. 146-209.
49. Wholey, J.S., Hatry, H.P., and Newcomer, K.E. (2004). Handbook of practical program evaluation (2nd ed.). San Francisco, CA: Jossey-Bass.