AC 2009-1972: MEASURING THE IMPACTS OF PROJECT-BASED SERVICE LEARNING

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Abstract

Project-based service learning (PBSL) has become an emergent opportunity for engineering education. In this paper both curricular and co-curricular/extracurricular community service activities related to engineering will be described. In this field there are a number of national programs, for example EPICS, Engineers Without Borders and Engineers for a Sustainable World, as well as university-specific opportunities. Student interest and involvement in these programs has been explosive. Yet, partly due to the grassroots development of many of these programs and to their rapid rise, there are scant findings on the impacts of these programs on engineering education. Preliminary findings suggest that students participating in PBSL early in college are retained in engineering at higher levels, women participate in voluntary PBSL opportunities at higher levels than their representation in engineering overall, PBSL fulfills a variety of ABET learning outcomes, and PBSL enhances student preparation to practice engineering design. The community impacts of these projects are outside the scope of this paper. However, the impacts of PBSL on community partners are of equal importance to the educational outcomes and should be evaluated.

This paper provides a broad review of existing PBSL programs, assessment methods used, and the impacts on students. A *summit* was held in early 2009 to summarize and leverage the collective expertise of the participants to identify desired outcome metrics, quality assessment methods, and key next steps needed in understanding the impacts of PBSL on engineering education. Those involved in PBSL seek guidance on how to better understand how these programs are affecting their students and institutions, and how to design the best experiences possible. The engineering professional community is interested in evidence indicating that graduates of these PBSL programs are achieving modern knowledge and skills. It may be that PBSL offers substantial promise for building the technological workforce needed by the nation.

Project-Based Service Learning

Project-based service learning is a form of active learning where students work on projects that benefit a real community or client while also providing a rich learning experience. Project-based learning (PBL) is learner focused.[1] In contrast to traditional PBL where a project is developed by the instructor and the learning path is fairly predictable, PBSL adds the community as a full partner and the outcomes are less clear. William Oakes notes: “the facilitation of the [PBSL] experience is more dependent upon capitalizing on teachable moments and learning opportunities than with traditional PBL. The service-learning therefore requires a more flexible curricular scaffolding to support the appropriate learning and presents additional assessment challenges since there is more uncertainty.”[2]

A number of recent books discuss service learning in engineering and other settings.[3, 4] For example, *The Guide to Service-Learning Colleges and Universities*[5], includes profiles of SL activities at more than 150 institutions. The main target of the book appears to be perspective college students who want to select a program that includes service-learning opportunities. About 50 of the colleges in the book include engineering or pre-engineering programs. Examples of programs profiled include the EPICS program at Purdue University; the Colorado School of Mines Minor in Civic Engagement and a special interest area in humanitarian engineering; Colorado State University's Service-Learning Graduate Teaching Certificate Program; and the University of Pennsylvania's CommuniTech. However, more important than a list of programs and courses is an understanding of the outcomes that can result from student engagement in PBSL.

Although this paper focuses exclusively on the students' educational outcomes, of equal importance are the impacts on the community partners. The community should be a true partner in the process and feel ownership of the project. This will help to ensure that they have reasonable expectations for the project outcomes and that an appropriate and sustainable solution is achieved. This is particularly challenging for international projects due to cultural differences that can complicate communication and understanding, and lack of close and frequent contact. Evaluations of community partner satisfaction and long term project benefits should be assessed. Impacts on the faculty mentoring the projects are also important but outside the scope of this paper.

Summit

The National Science Foundation funded a Summit on PBSL that was held in February 2009. Participants included those that were invited due to their high profile in engineering PBSL and educational assessment. Potential participants were also solicited via the email List Serve of the American Society for Engineering Education (ASEE) Educational Research Methods (ERM) Division, and Summit organizers distributed this call to others. This call resulted in 30 applicants. Applicants supplied a two-page CV and statement of interest. Some information from these applications has been included where appropriate in this summary paper.

After approximately 20 participants in the Summit were identified, participants were asked to complete a pre-summit questionnaire to learn more about their PBSL activities and assessments at their institutions. Some of the information provided by the participants has been included in this summary paper, with appropriate credit and citation given. Participants were also asked to identify the references that they believed were most helpful, and these have been compiled and are reported herein.

Service Learning Programs Integrated Across Curricula

There are a number of examples of PBSL programs that have been widely integrated across an entire engineering college. A few of these programs are highlighted below.

EPICS

EPICS (Engineering Projects In Community Service) is a program where students work in teams to design solutions for local communities facilitated through non-profit organizations that serve as project partners. The EPICS program was started at Purdue University in the School of Electrical and Computer Engineering in 1995 and now the National EPICS program includes at least 14 more universities. At Purdue these courses are available for 1 to 2 credits each semester across all four years of the B.S. curriculum. The courses are counted toward degree requirements differently by various majors as technical electives, free electives, etc. with various credit restrictions. EPICS teams generally include 8 to 20 students, vertically integrated across all years of the bachelor's degree. Typically multiple projects are conducted with the same community partner over a number of years. At Purdue, EPICS includes a 2-hour per week meeting with all team members and a 1 hour per week lecture or skill session. Assessments include student self-assessments of achievement of learning objectives that are graded on a scale of A to F, summative assessments where students indicate the 3 most valuable things they learned, and the level of satisfaction of project partners.[2, 6, 7]

SLICE

The Service-Learning Integrated throughout a College of Engineering (SLICE) program at the University of Massachusetts Lowell led by Professor John Duffy (2007) is an example of incorporating SL into existing required courses. This program aims to incorporate PBSL projects into existing courses throughout the curriculum so that students have at least 1 course every semester with SL. While this has not yet been achieved for all majors, some are very close. For example in 2006-2007 required courses for students majoring in Electrical Engineering included SL every semester except for second semester 1st year and first semester sophomore year. To date, a partnership with the Village Empowerment Program in Peru has been integrated into 25 courses. Examples of courses with PBSL include Introduction to Engineering; Chemical Engineering Heat Transfer and Materials; Civil Engineering Transportation, Probability & Statistics, Soil Mechanics, and Environmental Engineering Fundamentals; Electrical Engineering Electronics I and Capstone; Mechanical Engineering Design Lab I and II, Kinematics, Conduction & Radiation, Convective Processes, Thermodynamics Applications; and in Plastics Engineering Statics, Process Lab I and II, Heat Transfer. In 2005-2006 SL was incorporated into a total of 38 undergraduate engineering courses taught by 32 professors and 5 teaching staff serving 721 undergraduate students. In 2006-2007 there were 39 undergraduate engineering courses that included SL taught by 31 faculty with a combined enrollment of more than 1250 students. The main approach of the SLICE program to integrate SL into existing courses is the opposite of the EPICS program which created a series of separate courses with SL projects. SLICE does include some specifically interdisciplinary PBSL courses in the Junior and Senior year, including Community-based Engineering Design Project II and III and the Intercollegiate Engineering Capstone Design Project. [8,9]

Global Perspective Program

Another example of a program with PBSL opportunities is Worcester Polytechnic Institute's Global Perspective Program.[10] The program requires three projects, which may be completed off-campus: 1 in the arts and humanities, the Major Qualifying Project, and the Interdisciplinary or Interactive Qualifying Project that explores inter-relationships between science and technology. Students typically spend 2 month abroad working full time on their project. The main method of assessment is faculty review of the student project report using a detailed evaluation rubric. The projects conducted off-campus via the Global Perspectives Program showed much stronger evidence of ABET criteria d (multidisciplinary teamwork), f (understanding of ethics and professional responsibility), i (lifelong learning), h (impact of engineering on society), and j (knowledge of contemporary issues).

Certificates and Minors

Both Penn State University and the Colorado School of Mines (CSM) offer certificates and minors in Humanitarian Engineering (http://www.engr.psu.edu/ece/index.htm; http://humanitarian.mines.edu/). The Penn State Engineering and Community Engagement Certificate is earned through 5 areas of study encompassing 11 to 13 credits. The Minor in Civil and Community Engagement requires 18 credits, or which the certificate courses can count. The program at CSM offers a Humanitarian Engineering Minor comprised of 27 credits including an ethics or philosophy course, an engineering cultures course, two courses in a region track (U.S., Latin America, Asia, Africa and Middle East), a technical elective, and 9 credits of engineering laboratory and senior design that is normally required for all engineers but conducted with SL projects for the minor.[11,12] The engineering cultures course is a particularly important element in the program.[13,14]

Discussion

The advantage of having a course or courses that are explicitly PBSL-oriented is that the student always knows what they are getting. When PBSL is integrated into standard courses, it seems that inclusion of the PBSL activities are instructor-specific and sometimes even semester specific. The instructor doesn't always have a community partner interested in a project related to the technical focus of the course and ready to comply with academic-calendar restrictions. However, when PBSL is integrated into standard coursework a greater population of students is exposed to this learning opportunity, not simply those "electing" to participate. It has not yet been fully determined what differences exist in those that self-elect to participate in PBSL. But it is probable that these students start at a different level of self awareness and possess different attitudes (perhaps in regards to Community Service Attitudes, as evaluated by the CSAS[15, 16] or other instruments).

Examples of PBSL in Capstone Design Courses

There are many examples of PBSL incorporated into capstone design courses. This appears to be the most common curricular model for PBSL. The projects include those for local clients, international communities, and projects related to Engineers Without Borders (EWB) and other service organizations. In some programs the courses always include a service-learning component (e.g., Lafayette College and Ohio University). In other programs PBSL is incorporated as appropriate (Tufts Civil and Environmental; University of Colorado Civil and Environmental; Gonzaga University Civil and Environmental; Michigan Tech University Civil and Environmental and Biomedical). For example, Larry Bland from John Brown University noted that water purification in Guatemala by slow-sand filtration provided two years of projects for students in the senior design course, funded through an EPA P3 grant.[17]

Another example is the International Senior Design course in Civil Engineering at Michigan Technological University, which has included PBSL since 2000.[18, 19] At Purdue University, electrical and computer engineering (ECE) students may be able to use three credits of EPICS coursework to fulfill the senior design requirements, if the project is managed by an ECE faculty advisor and approved.[2] Many times the SL projects used in the capstone design courses relate to on-going projects facilitated by non-profit organizations such as EWB; allowing these projects to move from independent learning to more organized models.

Examples of PBSL in First-Year Courses

Many first year courses include PBSL components. A few examples are highlighted in Table 1. In the First Year Projects course at the University of Colorado at Boulder, some sections include PBSL activities. Students are generally unaware of what projects they will work on when they register for specific sections of this course, so the course does not self-select "service oriented" students. Required courses at Michigan Tech and Cal Poly also incorporate PBSL, so all entering first year students in those majors participate. In contrast, students can elect to take the EPICS course at Purdue University. The voluntary versus compulsory nature of the SL courses and activities should be considered when interpreting assessment data on student attitudes and motivation.

Table 1. PBSL in First Year Engineering Courses

Course Title	University	Majors	Required	Enrollment	Example of activities
Experiences in Environmental Engineering	Michigan Tech	EVEN	Yes	55 in 2008; 31% female, 15% international	conceptual design of engineering solution to a need in a developing community Outcomes: presentation
First Year Projects	University of Colorado – Boulder	all	Varies by major	~25 per section each semester	Some sections do PBSL including assistive technologies for handicapped, interactive museum displays, technologies for developing communities
EPICS EPCS 101	Purdue University (and others)	all	No		Partner with local communities; on-going projects and vertically integrated teams
Freshman Design	Cal Poly	Materials Eng.	Yes	50-60/yr	Partner with local NGOs; examples include solar water heater project

Examples of PBSL in Other Courses

PBSL activities have been incorporated as an element in a variety other courses, ranging from the sophomore to senior year. Some examples of these courses are provided in Table 2 below; the list is not intended to be exhaustive but merely to give representative examples. In required courses with a specific technical focus, PBSL is typically incorporated at the discretion of the instructor. For example, in Prof. Joel Burken's Solid Waste Management course 18 students worked on project for the local community and Missouri University of Science and Technology (http://ugs.mst.edu/documents/FS_2008_ASL_Courses.pdf). As part of the SLICE program, students in the junior-level Environmental Engineering Laboratory analyzed road salt and other chemicals in roadway runoff for the Town of Dunstable. The next semester in the Water Resources Engineering course, the same students used hydrology to understand chloride levels in the Town of Dunstable's wells.[9]

Table 2. Example courses that have Integrated PBSL

Course	Institution	Instructor	Years	SL projects required for all students in course?
Solid Waste Management	Missouri Science & Technology	Joel Burken	2008	Yes
Site Remediation Techniques[20]	Tufts University	Chris Swan	1999-2002	
Environmental Engineering Lab	Univ. Massachusetts - Lowell	Cliff Bruell	2006-	Yes
Water Resources Engineering	Univ. Massachusetts - Lowell	Jackie Zhang	2006-	Yes
Introduction to Materials and Materials Lab	University of Dayton	Margaret Pinnell		1 in 6 semesters an SL project

PBSL can also serve as the main focus for a course. These are generally upper-division/senior level electives. Examples include: Sustainable Engineering (Sharon Jones, Lafayette College), Issues in Professional Engineering Practice (Chris Swan, Tufts University)[21], Low Impact Development (Brad Striebig, Gonzaga University), Water Resources Assessment (Bill Moeller, University of Massachusetts-Lowell), Engineering Design and Appropriate Technology (ETHOS International service-learning internships) and Special problems/Service Learning in Mechanical Engineering (Margaret Pinnell, University of Dayton).

Examples of Related Extracurricular Activities

Although SL is by definition an activity integrated into credit-bearing courses, in many cases projects can pass between curricular and extracurricular activities. The most striking examples of extracurricular PBSL activities are projects conducted with Engineers Without Borders (EWB; www.ewb-usa.org) and Engineers for a Sustainable World (ESW; www.esustainableworld.org/). These organizations have exploded in popularity with over 140 and 20 established student chapters, respectively, and more than 6000 student members. These organizations help facilitate community service opportunities for students. While these are generally extracurricular activities, EWB also supports projects in senior design classes. The University of Colorado – Boulder and Lafayette College are two examples where EWB projects are run concurrently as capstone design projects and extracurricular projects. The International Center for Appropriate and Sustainable Technology, iCAST, is another organization that facilitates matching Universities with PBSL opportunities. Students in engineering, business, and communications at 19 Universities and Colleges have partnered with iCAST and communities or businesses via course-based projects and independent learning. Currently the bulk of their projects are in the energy sector, and partnering with rural and low income areas in the U.S. (www.icastusa.org). Some universities have a culture of student involvement on extracurricular community service. For example, at John Brown University students conduct mission work without course credit, and starting in 2009 all students will be required to have an intercultural experience prior to graduation (www.jbu.edu). Assessment of student learning that occurs due to participation in extracurricular community service projects is of interest and may lead to greater integration of these activities into credit-bearing courses.

Examples of Assessment Methods

Program assessment is a vital activity in order to determine the outcomes of student engagement in PBSL. These outcomes can be grouped into four general categories: (1) knowledge, (2) skills, (3) attitudes and identity, and (4) program issues such as recruitment, retention, and diversity. Different assessment methods are more commonly applied in some settings than others. This section will not attempt to present all possible assessment methods, but rather highlight some that have been applied to PBSL evaluation.

Assessment methods have been more commonly and rigorously applied to course-based PBSL than extra-curricular activities. This has been largely driven by ABET accreditation issues.[22] Assessments should be tempered by the fact that students may get irritated if they feel like "lab rats" being evaluated. So when assessments are imbedded and beneficial to the students this is most appropriate. Course assignments can be readily used to assess knowledge and skills. In design classes, assessment of the technical quality of the student learning is evaluated via standard grading of written reports and oral presentations. Sometimes, student attitudes can also be revealed in course assignments. In some cases peer-assessment of reports or peer evaluations of professional skills may be beneficial. Asking the students to self-assess improvements in ABET-related knowledge and skills (for example, communication skills) is common, but less reliable than independent evaluation. Assessments based on assignments submitted by students do not generally require IRB approval as they are the standard grade-determining outcomes from the course.

Reflective essays or journals are commonly used in both courses and extracurricular EWB and similar service projects and trips. The exercise can benefit the student by forcing them to reflect on the experience, serve as a "catharsis" to vent when negative experiences occur, etc. Most service-learning pedagogy explicitly indicates that student reflection is a necessary part of the learning process. Without thoughtful reflection, the full value of the SL experience may not be realized.[23] These same reflective essays can serve as an assessment instrument. They yield rich qualitative information beyond the student learning of technical topics, and indicate changes in attitude and identity of the students. These essays can be coded to yield quantitative findings from the qualitative student statements.[24]

Vast arrays of techniques have been applied to evaluate student attitudes and identity. Scoring rubrics have been used in the Engineering Cultures course.[14] This is similar to the idea of essay coding. Most commonly, attitudes have been assessed using written surveys with a series of questions that respondents answer on a Likert scale. It is important to ensure that such instruments are validated. These surveys vary greatly in length, complexity, costs, previous use in engineering education or other contexts, and type of information provided. In a PBSL context, particularly international projects, it is of interest to assess cultural competency, cultural sensibility, and cultural humility (all closely related ideas). Examples of various assessment surveys include:

- Academic identity scale: academic discipline as identity[25]
- Beliefs, Events, and Values Inventory [26]
- Commitment to social justice: social justice as identity[27, 28]
- Community Service Attitudes Scale (CSAS) [15, 16]
- Cross-Cultural Adaptability Instrument (CCAI) [29, 30]
- Cultural Diversity Attitudes Scale (CDAS): culture, ethnicity, diversity; developed for medical school use[31]
- Defining Issues Test (DIT): moral reasoning[32, 33]
- Design self-efficacy instrument: confidence in design[25, 34]
- IDI: worldview orientation toward cultural differences [35]
- Learning self-efficacy instrument: confidence in self-directed learning[25, 36, 37]
- Miville-Guzman Universality-Diversity Scale (MGUDS-S) survey – cultural competency[38, 39]
- Need for Cognition Scale: self-directed learning measure[40]
- Pittsburg Freshman Engineering Attitudes Survey (PFEAS) [41, 42]
- Situational Intrinsic Motivation Scale: base motivation measure [43]
- Student Self-Determination Scale (SDSS) [44]
- Student Thinking & Interacting Survey [27, 28]

Bland notes that quantitative data such as the IDI should be linked with qualitative information, because the IDI can show that movement is taking place along the developmental continuum but it cannot tell us why so that appropriate course changes can be made. This idea was echoed by Laura Hahn, that it is helpful to have multiple assessment methods. Hahn also noted that it is helpful to have students help design the assessments.

Examples of PBSL Impacts

PBSL experiences should benefit both the community being served and the student participants. The benefits to the community partners can vary significantly, and the partners should have realistic expectations. A key concern is when SL activities involve designs for developing communities globally which can have public health implications. In addition, the long-term sustainability of projects conducted for communities is critical.[45] These impacts of PBSL are outside the scope of this paper, but should be carefully evaluated. There are also effects on the faculty that engage in and lead these PBSL activities, but these effects have been largely unexplored. In general, faculty report that PBSL is motivating, requires more time than other pedagogies, and is not rewarded in evaluation, promotion, and tenure.

Many professors who use PBSL in their courses noted that the PBSL learning context is more motivating to students than standard PBL, laboratory, or classroom pedagogies, and greater motivation is often linked to stronger learning outcomes.[49] The potential impacts of PBSL relevant to the students can be grouped into 5 main categories: student knowledge, student skills, student attitudes, recruiting/retention/diversity, and post-educational professional performance. These areas are each briefly explored below.

Knowledge and Skills

Knowledge and skills are, generally, fairly easy to directly measure by common assessments used in nearly all engineering courses. Evaluations of these outcomes are usually conducted via graded reports, presentation, and other student work. Knowledge and skill outcomes link directly to the expectations of our degree programs as articulated by ABET[22], the American Society of Civil Engineers (ASCE) and American Academy of Environmental Engineers (AAEE) Body of Knowledge, etc.[46, 47] PBSL can achieve the same technical knowledge as other pedagogies, assuming that a project that encompasses the desired knowledge areas is selected. PBSL is generally very effective at helping students develop non-technical skills such as teamwork, communication, leadership, and project management. Interpersonal skills are at the heart of many of these previous skill sets, and will serve the student well in their professional and personal lives. These are similar to the impacts identified in Problem-Based learning and design projects in general, and not unique to PBSL. But the breadth of these skills is enhanced in PBSL. For example, communicating with both technical and non-technical audiences deepens these skills. PBSL also seems to result in much greater student understanding of professional and ethical responsibility.

Kremer notes that it is important to independently evaluate these rather than rely on student self-assessments whenever possible. Self-reported “significant” gains in teamwork and communication abilities, for example, may not be confirmed by peer evaluations or instructor observations of oral presentations. It is also dangerous to infer that a student has achieved a certain development level in a professional skill from their behavior in a single instance due to the situational-dependent nature of many behaviors. Kremer believes “there is a lack of authentic methods for developing and assessing any skills beyond communication and teamwork.” He believes that a performance review approach, coupled with an assessment of students’ ability to describe example behaviors for numerous skill areas, is effective. The achieved performance is then compared to expectations, followed by the development of plans to improve performance in a specific skill area.[48] Other researchers have also focused attention on how to measure professional skills.[54]

The added value of PBSL in engineering education forces students to recognize that all aspects of design (technical and non-technical) are important. In PBL experiences frequently technical aspects dominate the projects and students still fail to fully grasp the equal and sometimes greater importance of non-technical issues. This is particularly important for civil and environmental engineers who frequently work on projects that directly serve the public and are funded by tax dollars. Therefore, the use of PBSL-oriented projects force students to “think outside the technical box” to develop appropriate and realistic designs. This requires them to go beyond a textbook and use greater creativity.

In an example of a non-traditional measure indicating improvement in understanding of professional ethics, Trevor Harding (personal communication) noted that students’ moral reasoning scores[56] are dramatically increased through PBSL, based on a pre/post test measures in a 1-year first year Materials design course. The final mean moral reasoning scores of the students who had participated in PBSL were statistically similar to national normative data for individuals with a Masters degree. Other outcomes in the ABET A-K criteria are also particularly difficult to measure, such as life-long learning.[52] Researchers should share effective ways to measure these attributes.

Attitudes and Identity

Attitudes are often harder to measure, particularly within the timeframe of a single course. Attitude changes will often manifest later after periods of self-reflection by the students. In this regard, the SLICE and EPICS programs with a long-term history, large numbers of student participants, and good assessment over time are ideal to identify potential attitude changes. For example, students come to realize that professional and social responsibilities go together (Swan[20]; SLICE[8, 9]; Kremer[48]). There are significant increases in perceptions of an obligation and personal empowerment to make changes in society. Students and faculty engaged in the SLICE program experienced increased sensitivity to the social, cultural, and environmental consequences of engineering decision making.[9] Similar findings are reported by Kremer (personal communication): >95% of students engaged in a PBSL capstone design experience self reported high awareness of the social impact of engineering, significant increases over self assessments with non-SL projects. Students also had an increased interest in volunteer opportunities and civic engagement. Students engaged in SL have also been shown to have increased self-confidence and self-esteem.[57] Further, engagement in PBSL may help transform how students perceive their identities as engineers. Engineers with a heart who truly care about society seems possible, rather than engineers as detached technocrats.[59, 60]

Recruiting, Retention, and Diversity

There is some indication that PBSL programs can help attract and retain a more diverse population of students in engineering. The SLICE and Village Empowerment (VE) program with Peru has attracted disproportionate participation from women and Hispanic students since 1998.[45, 50] Duffynotes that 36% of the 71 engineering students were female, in comparison to 10.5% female undergraduate enrollment at UML. Hispanics represented 28% of the engineering students participating in the VE program, compared to approximately 8 to 9% in the engineering student population nationwide.[51] Similarly, in the EPICS program at Purdue University, 20% of the ECE and ME student participants are women, compared to 10 to 12% in these majors overall; representation of females majoring in computer science in EPICS is 3 times higher than the major overall.[6, 53] Brad Striebig (personal communication) noted that PBSL projects in senior design and his Low Impact Development elective course had about double the typical ratio of women in engineering at Gonzaga. These examples indicate the popularity of these experiences with women and minorities, but it is unclear if this translates into any recruiting or retention in engineering overall. Rather, it indicates that PBSL effectively recruits these populations from within engineering. Increased retention of students, and particularly minorities, through engagement in PBSL may be realized due to a variety of underlying factors including more direct mentoring by faculty, forming bonds with other students when PBSL is conducted in a team-based setting, etc.[55, 58] A 2008 survey (n=112) indicated that about half of the participants (48.3%) in Michigan Tech's D80 Center (www.d80.mtu.edu) activities stated that they attended Michigan Tech explicitly because of the programs. This is the most compelling data on recruiting. However, it is still unclear if these programs will help recruit students into engineering that otherwise would have gone into other majors and/or career fields.

Professional Performance

There is virtually no quantitative assessment of the benefits of PBSL experiences to professional trajectory. The results of the SLICE program indicated in paired t-tests of pre- and post-surveys of 114 students in 2005-2006 that there was a significant increase in students reporting the importance of a career that involves helping people (personal communication). Unsolicited, informal student feedback from participants in EWB at the University of Colorado at Boulder also indicate that some students have changed their planned career path, finding themselves dissatisfied with traditional engineering consulting jobs.

There are some indications that employers value PBSL experiences. CDM pays an engineer who is officially designated as a company coordinator for EWB (http://www.cdm.com/about_cdm/news_and_events/news/cdm_launches_ewb_program.htm). Other engineering companies are high level sponsors of EWB including CH2M Hill, Washington Division of URS Corporation, Black & Veatch, Carollo Engineers, GeoEngineers, TetraTech, Walter P. Moore, Kleinfelder, and AECOM (http://www.ewb-usa.org/sponsors_partners.php). Other companies actively support the involvement of their employees as mentors of EWB student teams or in the professional EWB chapter activities. In some cases the employer will pay for time on a matching basis that the employee donates to the EWB activities. It is not fully clear if companies view this as a way to attract and retain qualified engineers, value the unique skills developed in engineers with these experiences, etc. Top management at Mortenson Construction has indicated that it values PBSL experiences in potential hires, and supports EWB-type activities among its employees as good training for work-related skills.

Future Directions

Those directly engaged in PBSL seem universally convinced of its merit. However, further work is needed to allow us to forecast the value of PBSL efforts and the sustainability of doing PBSL in engineering education. The skills that the students develop may be deeper than revealed by a basic ABET-style inventory. For example, how do PBSL experiences impact the ability to work as a team, particularly in terms of social capital development? Do students engaged in PBSL develop a deeper understanding of the importance of local context in solving engineering problems? Beyond generic improvements in communication skills, are PBSL participants more facile at communicating with non-technical stakeholders about engineering projects? It is also of interest to determine if the PBSL efforts that the students experience in school translate into career-long behaviors and tendencies. Are PBSL attributes and skills (i.e., non-technical) immediately relevant to a student's job or career efforts? Do employers find these skills of value for early career engineers? Answers to these questions can provide evidence that PBSL is of value for a sustainable engineering education across a career. Other important questions that have yet to be answered are how PBSL affects students' identity as engineers, which could impact retention of these students in engineering as a major and as a career. All of these elements could vary with the type of PBSL experience. The long term impacts on the community partners should also be explored, particularly in regards to engineering in global settings where what appears at its face to be a technical impact on the community can have broader ripple effects and unintended "social engineering" consequences that should be considered and discussed with community partners. The engineering community needs to come together to research PBSL to fully understand its benefits and limitations.

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Bibliography

1. Thomas, J.W. 2000. A Review of Research on Project-Based Learning. The Autodesk Foundation. http://www.bobpearlman.org/BestPractices/PBL_Research.pdf
2. Oakes, William. 2009. PBSL Pre-Summit Survey. (personal communication)
3. Lima, M. and W. Oakes. 2006. *Service-learning: Engineering in Your Community*. Great Lakes Press. 2006.
4. Tsang, E., ed. 2000. *Projects that Matter: Concepts and Models for Service-Learning in Engineering*, Washington D.C., AAHE.
5. Student Horizons. 2008. *Guide to Service-Learning Colleges & Universities*. Kendall/Hunt Publishing Company. Dubuque, IA.
6. Coyle, E.J., L.H. Jamieson, and W.C. Oakes. 2005. EPICS: Engineering Projects in Community Service. International Journal of Engineering Education. 21 (1), 1-12.
7. Immekus, J.C., S.J. Maller, S. Tracy, and W. Oakes. 2005. Evaluating the Outcomes of a Service-Learning Based Course in an Engineering Education Program: Preliminary Results of the Assessment of the Engineering Projects in Community Service – EPICS. Proceedings of the ASEE Conference & Exposition. 16 pp.
8. Duffy, J., D. Kazmer, L. Barrington, J. Ting, C. Barry, X. Zhang, D. Clark, A. Rux. 2007. Service-Learning Integrated into Existing Core Courses Throughout a College of Engineering. Proceedings of the 2007 ASEE Annual Conference and Exposition. AC 2007-2639. 34 pp.
9. Duffy, J., W. Moeller, D. Kazmer, V. Crespo, L. Barrington, C. Barry, C. West. 2008. Service-Learning Projects in Core Undergraduate Engineering Courses. International Journal for Service Learning in Engineering. 3 (2), 18-41.
10. Mello, N., D. DiBiasio, and R. Vaz. 2007. Fulfilling ABET outcomes by sending students away. Proceedings of the 2007 ASEE Annual Conference and Exposition. AC 2007-500.
11. Skokan, C. and D. Munoz. 2007. Humanitarian Engineering Program – Challenges in the Execution of Remote Projects. International Conference on Engineering Education (ICEE 2007), Coimbra, Portugal, Sept. 307. paper 204. http://icee2007.dei.uc.pt/proceedings/papers/204.pdf
12. Munoz, D.R. 2006. Building a Humanitarian Engineering Program. 5th Annual American Society for Engineering Education (ASEE) Global Colloquium on Engineering Education, Rio de Janeiro, Brazil, Oct. 9-12, 23 pp.

13. Parkhurst, R., B. Moskal, G. Downey, J. Lucena, T. Bigley, and S. Elber. 2008. Engineering cultures: Comparing student learning in on-line and classroom based implementations. International Journal of Engineering Education. 24 (5), 955-964.
14. Downey, G.L., J. Lucena, B. Moskal, R. Parkhurst, T. Bigley, C. Hays, B. Jesiek, L. Kelly, J. Miller, and S. Ruff. 2006. The globally competent engineer: Working effectively with people who define problems differently. Journal of Engineering Education. 95 (2), 107-122.
15. Shiarella, A.H. and A.M. McCarthy. 2000. Development and Construct Validity of Scores on the Community Service Attitudes Scale. Educational and Psychological Measurement. 60 (2), 286-300.
16. Shiarella, A.H., A.M. McCarthy, M.L. Tucker. 1999. Refinement of a Community Service Attitude Scale. Paper presented at the Annual Meeting of the Southwest Educational Research Association. 35 pp.
17. Bland, Larry. 2008. Final Report: Sustainable Community Development – Water Slow-Sand Filtration. US EPA Grant Number SU833544. http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/8625/report/F
18. Hokanson, D.R., L.d. Phillips, and J.R. Mihelcic. 2007. Educating Engineering in the Sustainable Futures Model with a Global Perspective: Education, Research, and Diversity Initiatives. International Journal of Engineering Education. 23 (2), 254-265.
19. Fuchs, V.J. and J.R. Mihelcic. 2007. Engineering Education for International Sustainability: Curriculum Design Under the Sustainable Futures Model. Proceedings of the ASEE North Midwest Sectional Conference.
20. Swan, C., T. Rachell, and K. Sakaguchi. 2000. Community-Based, Service Learning Approach to Teaching Site Remediation Design. ASEE Annual Conference and Exposition, June, St. Louis, MO.
21. Swan, C. and J. Carroll. 2008. Beyond Their Technical Capabilities: Providing Student Exposure to Professional, Communication, and Leadership Skills. ASEE Annual Zone I Conference, West Point, NY, March.
22. ABET. 2007. Criteria for Accrediting Engineering Programs. Effective for Evaluations During the 2008-2009 Accreditation Cycle. ABET Engineering Accreditation Commission. www.abet.org
23. Moffat, J. and R. Decker. 2000. Service-Learning Reflection for Engineering: A Faculty Guide. In E. Tsang, ed. Projects that Matter. AAHE. p. 31-39.
24. McCormick, M., C. Swan, and D. Matson. 2008. Reading Between the Lines: Evaluating Self-Assessments of Skills Acquired During an International Service-Learning Projects. ASEE Annual Conference and Exposition, Pittsburgh PA., June.
25. Harding, Trevor. 2009. Assessments Developed In-House at California Polytechnic University – San Luis Obispo. PBSL Pre-Summit Survey. (personal communication)
26. Shealy. 2004. A model and method for "making" a combined-integrate psychologist: Equilintegration (EI) theory and the Beliefs, Events, and Values Inventory (BEVI). J. Clin Psych. 60(10), 1065-1090.
27. Nelson Laird, T.F., M.E.Engberg, and S. Hurtado. 2005. Modeling accentuation effects: Enrolling in a diversity course and the importance of social action engagement. The Journal of Higher Education. 76(4), 448-476.
28. Engberg, M.E. and M.J. Mayhew. 2007. The Influence of first-year "success" courses on student learning and democratic outcomes. Journal of College Student Development. 48 (3), 241-258.
29. Kelley, C. and J. Meyers. 1995. The Cross-Cultural Adaptability Inventory. Minneapolis, MN: National Computer Systems.
30. Davis, S.L. and S.J. Finney. 2006. A factor analytic study of the cross-cultural adaptability inventory. Educational & Psychological Measurement. 66(2), 318-330.
31. Dogra, N. and N. Karnik. 2003. First-year medical students' attitudes toward diversity and its teaching: an investigation at one U.S. medical school. Academic Medicine. 78(11), 1191–200.
32. Rest, James. 1979. *Development in Judging Moral Issues*. University of Minnesota Press. ISBN 0816608911.
33. Rest, James, D. Narvaez, M. Bebeau and S. Thoma. 1999. DIT-2: Devising and testing a new instrument of moral judgment. Journal of Educational Psychology. 91 (4), 644–659.
34. Bergin, D., S. K. Khanna and J. Lynch. 2007. Infusing Design into the G7-12 Curriculum - Two Example Cases. International Journal of Engineering Education. 23 (1), 43-49.
35. Hammer, M.R., M.J. Bennett, and R. Wiseman. 2003. Measuring intercultural sensitivity: The intercultural development inventory. International Journal of Intercultural Relations. 27(4), 421-443.
36. Bandura, A. 2006. Guide for Constructing Self-Efficacy Scales in Self-Efficacy Beliefs of Adolescents. F. Pajares and T. Urdan. Information Age Publishing. Greenwich CT. http://www.des.emory.edu/mfp/self-efficacy.html
37. Zimmerman, B.J., A. Kitsantas, and M. Campillo. 2005. Cuestionario de Intereses Profesionales Revisado. Evaluar. 5 (octubre), 17-20.

38. Fuertes, J.N, M.L. Miville, J.J. Mohr, W.E. Sedlacek, D. Gretchen. 2000. Factor structure and short form of the Miville-Guzman Universality-Diversity Scale. Measurement & Evaluation in Counseling and Development. 33(3), 157-170.
39. Miville, M.L., P. Holloway, C. Gelso, R. Pannu, W. Liu, P. Touradji, and J. Fuertes. 1999. Appreciating Similarities and Valuing Differences: The Miville-Guzman Universality-Diversity Scale. Journal of Counseling Psychology. 46(3), 291-307.
40. Cacioppo, John T., Richard E. Petty, Jeffrey A. Feinstein and W. Blair G. Jarvis. 1996. Dispositional Differences in Cognitive Motivation: The Life and Times of Individuals Varying in Need for Cognition. Psychological Bulletin. 119 (2), 197-253.
41. Besterfield-Sacre, M.E., C.J. Atman, L.J. Shuman. 1995. How Freshman Attitudes Change During the First Year. American Society for Engineering Education Conference Proceedings, 157-163.
42. Besterfield-Sacre, M.E., C.J. Atman, and L.J. Shuman. 1998. Student Attitudes Assessment. Journal of Engineering Education. 87(2), 133-141.
43. Guay, R., J. Vallerand and C. Blanchard. 2000. On the assessment of situational intrinsic and extrinsic motivation: The Situational Motivation Scale (SIMS). Motivation and Emotion 24 (3), 175–213.
44. Field, S., and A. Hoffman. 1994. Development of a model for self determination. Career Development for Exceptional Individuals. 17, 159–169.
45. Duffy, J. 2008 Village Empowerment: Service-Learning with Continuity. International Journal of Service Learning in Engineering. 3 (2), 1-17.
46. ASCE. 2008. Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future. Second Edition. American Society of Civil Engineers. www.asce.org.
47. AAEE. 2008. Draft Environmental Engineering Body of Knowledge. American Academy of Environmental Engineers. www.cecs.ucf.edu/bok/publications.htm, accessed June 2008.
48. Kremer, G. and D. Burnette. 2008. Using Performance Reviews In Capstone Design Courses For Development And Assessment Of Professional Skills. Proceedings of the 2008 American Society for Engineering Education Annual Conference & Exposition, Paper 1041, Session 3525.
49. Vanasupa, L., K.C. Chen, J. Stolk, R. Savage, T. Harding, B. London, and W. Hughes. 2008. Converting Traditional Materials Labs to Project-Based Learning Experiences: Aiding Students' Development of Higher-order Cognitive Skills. Journal of Materials Education. 30 (3/4), 8 p.
50. Barrington, L. and J. Duffy. 2007. Attracting under-represented groups to engineering with service-learning. Proceedings of the American Society for Engineering Education Annual Conference & Exposition. AC 2007-2871.
51. National Science Foundation. 2003. Women, Minorities, and persons with disabilities in science and engineering: 2002. Division of Science Resources Statistics. NSF 03-312. Arlington, VA.
52. S. Juisto and D. DiBiasio. 2006. Experiential Learning Environments: Do They Prepare Our Students to be Self-Directed, Life-Long Learners? J. Eng. Educ. 95, 195-204.
53. Matusovich, H., D. Follman, and William Oakes. 2006. Work in Progress: A Student Perspective – Why Women Choose Service-Learning. 36th ASEE/IEEE Frontiers in Education (FIE) Conference. Session S2G-7 to 8. Oct. 28-31. San Diego, CA.
54. Shuman, L.J., M.E. Besterfield-Sacre,and J. McGourty. 2005. *The ABET "Professional Skills" – Can They Be Taught? Can They Be Assessed?* Journal of Engineering Education, January, pp.41-55.
55. Yeh, L. 2008. Service-Learning and College Persistence of Students from Low-Income, First-Generation Backgrounds. Paper presented at the *Annual Meeting of the American Educational Research Association*. New York City, March 24-28.
56. Mayhew, M.J. and P. King. 2008. How curricular content and pedagogical strategies affect moral reasoning development in college students. Journal of Moral Education. 37 (1), 17-40.
57. Gokhale, S. and M. O'Dea. 2000. Effectiveness of Community Service in Enhancing Student Learning and Development. Proceedings of the ASEE Annual Conference and Exposition.
58. Hernandez, J.C. and M.A. Lopez. 2004/2005. Leaking pipeline: Issues impacting Latino/a college student retention. Journal of College Student Retention. 6 (1), 37-61.
59. Catalano, George D. and C. Baillie. 2006. Engineering, Peace and. Social Justice: A Revolution of the Heart. ASEE 2006 Annual Conference and Exposition.
60. Amadei, Bernard. 2007. 'Engineering with heart' for the world's poor. Interview on Earth+Sky radio show. http://www.earthsky.org/radioshows/51785/engineering-heart