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Spectra of Learning Through Service Programs

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Spectra of Learning Through Service Programs

Abstract
Engineering students have a growing number of opportunities to engage in service-learning and co-curricular service activities. Because of the range of opportunities that exist for students to engage in community service activities, the umbrella term Learning Through Service (LTS) has been created. As these types of opportunities increase, the range and diversity of these initiatives has not been well documented. While some more established programs have published extensively on their program characteristics and assessment outcomes (i.e. SLICE at the University of Massachusetts Lowell and EPICS at Purdue), many newer and emerging programs have not yet have published any information. In fact, some of these LTS activities are not routinely included in courses but are integrated intermittently by motivated faculty -- sometimes without widespread recognition within their own college or university. This paper presents an initial summary of some of the lesser publicized LTS activities based on a literature search and two recent workshops associated with the NSF-grant on Engineering Faculty Engagement in Learning Through Service (EFELTS). Emerging LTS patterns, opportunities, challenges, and resources are summarized to provide an expanded view of the landscape of what is currently happening in engineering.

Background
Learning Through Service (LTS) is an umbrella term that encompasses service-learning (SL) and extracurricular activities such as Engineers Without Borders (EWB) that teach students valuable skills while also benefitting community partners. Although EWB is primarily an extra-curricular activity for students, some projects are designed and structured to teach specific skills and include reflective writing assignments for student participants. Research has shown that LTS activities can successfully meet a variety of learning outcomes for engineering students and provide benefits to community partners.[6,14] This paper will present a summary of LTS activities based on a literature search and recent activities associated with the NSF-grant on Engineering Faculty Engagement in Learning Through Service (EFELTS).

The number of service-learning and co-curricular service activities in engineering appear to be growing; see Figure 1. The number of ASEE conference papers that were found using the search terms “service learning” ranged from 1 to 123 in any single year. Papers on Engineers Without Borders (EWB) first appeared in 2003. Using the Web of Science search engine, peer-reviewed journal papers found using the search terms *“service learning” AND engineering* first appeared in 1999 with a peak in a single year of 6 papers in both 2007 and 2011. The *International Journal for Service Learning in Engineering: Humanitarian Engineering and Social Entrepreneurship* is an entire journal devoted to these projects, programs, and research. It began in 2006 and typically publishes two issues per year.

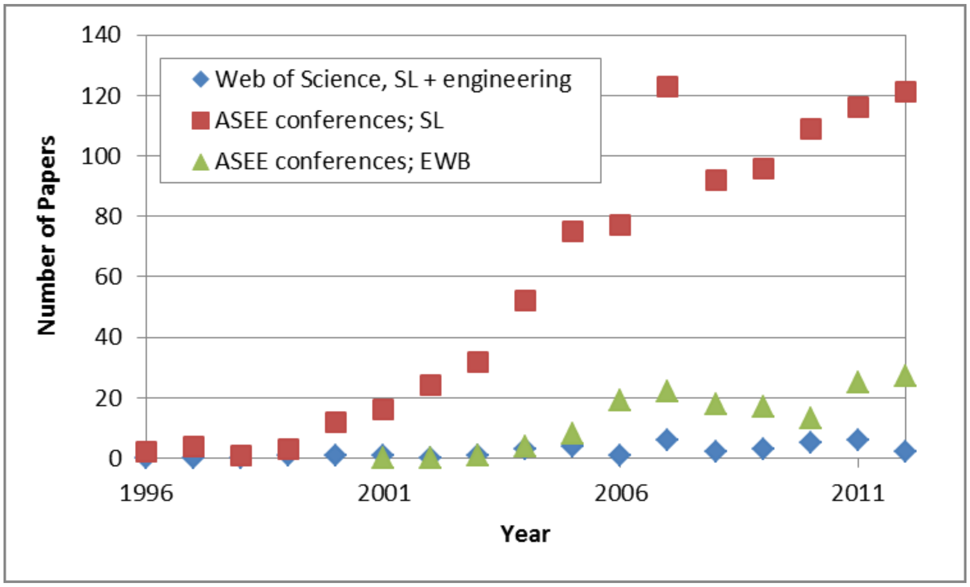

Figure 1. Number of publications found using searches on engineering, service learning, and/or EWB via the Web of Science citation index or ASEE conference proceedings.

Curricular Efforts

LTS in engineering has been integrated into a wide range of required and elective courses at various universities. In SLICE at the University of Massachusetts Lowell, SL projects have been integrated into a wide variety of core, required courses across multiple majors, including statics, dynamics, thermodynamics, fluids, heat transfer, and materials in chemical engineering, plastics engineering, mechanical engineering, and/or civil engineering.[13,14] Examples of SL projects in these core courses are provided in Table 1. More commonly, SL projects are integrated into projects-based or design courses at levels ranging from first-year to capstone design to graduate. New elective courses specific to service projects focused around sustainability, global issues, and/or appropriate technology have also been developed.

Table 1. Examples of LTS Courses

Course	SL Component	Reference(s)
Statics and Dynamics, Lewis-Clark State College	Wheelchair ramp design/build	23
Heat Transfer, Mechanical Engineering, University of Detroit Mercy	installed heat saving devices at windows and doors in homes; calculated decreases in heat loss due to home modifications	15, 16
First year Engineering Design, Northeastern University	Experiential SL projects (and also theoretical SL and non-SL)	18
First Year Engineering Projects, University of Colorado Boulder	Projects for local daycares, assistive technology device for a child	34
First-year engineering course, Berkeley	5-week module K-12 SL at local science museum	33
Sophomore Design, James Madison University	Mobility projects for local disabled children	27

Course	SL Component	Reference(s)
Capstone Design in Electrical, Computer, and Mechanical Engineering, University of Wyoming	Assistive technology devices	3
Design with the Developing World, University of Iowa	Habitat for Humanity, elementary schools, emergency shelter projects with local partners	21
Engineering and Global Development, Smith College	Local SL program on oven emissions	31
idesign, Michigan Tech	Infrastructure projects with communities throughout Latin America	28
Projects in Community Service Engineering, Penn State	Projects with State College and Kenya	8

There are also a number of examples of faculty incorporating into coursework what are typically extra-curricular LTS activities, such as Engineers Without Borders (EWB) or Engineers for a Sustainable World (ESW). A few examples are provided in Table 2. This overlap between SL and extracurricular activities is one reason that this paper uses the lens of LTS.

Table 2. Examples of Courses that have Integrated Primarily Extra-Curricular Activities

Extra-Curricular Activity	Course Integration	Reference(s)
Engineers Without Borders (EWB) project	Junior and Senior Engineering Clinics, Rowan University	17; 26
Engineers Without Borders (EWB) project	Global Projects in Engineering and Technology, Brigham Young University	22
Engineers Without Borders (EWB) project	Civil Engineering Capstone Design, Rose-Hulman	1
Engineers for a Sustainable World (ESW) project	Design for a Sustainable World, Stanford University	2

Extra-Curricular

Finally, there are also a number of extracurricular LTS activities that have been shown to yield positive impacts for both student learning and community partners. Jaeger[20] found that an EWB project experience led to increased cultural awareness, teamwork abilities, networking outside their field, and understanding of ethics and responsibility as an engineer. McCormick et al.[25] reported advancement in leadership, teamwork, communication and problem solving skills by students involved in an EWB project related to green-building in Ecuador.

Summary

As mentioned previously, a few of the more established initiatives have published extensively on their program characteristics and assessment outcomes, i.e. SLICE at the University of Massachusetts Lowell[13,14] (cited in 24 ASEE conference papers), EPICS at Purdue[9] (cited in 187 ASEE conference papers), the civil engineering program at the University of Vermont [10,11,12,19,32] (cited in 9 ASEE conference papers and peer-reviewed papers). These programs benefit from large dedicated staff and faculty, aiding their administration and dissemination efforts. Many newer and emerging initiatives have not yet published any information. In fact, some of these

LTS activities are integrated only intermittently when motivated faculty lead the courses -- often without widespread recognition within their own college or university.

To address the growing interest in engineering LTS an NSF-sponsored meeting of experienced LTS practitioners was held in September 2011. Participants were invited based on their publications in the areas of service-learning or co-curricular LTS. The group was roughly split between self-identified program designers and education assessment experts. At this meeting, a group of participants developed various characteristics that could be used to define, compare, and contrast different programs.[24] This paper was provided to participants at two 2012 NSF-sponsored workshops designed to help further develop LTS faculty capacity for program design, management, and assessment. The participants of these workshops self-rated their own LTS programs on a number of these spectra. The process and results of these LTS program analyses are described in detail in the remainder of this paper.

Process

Two NSF-sponsored workshops on LTS in engineering were held in 2012 and included 36 participants representing 24 universities and about 30 different LTS courses and/or programs from around the U.S. The participants submitted an application to participate, and multiple applicants from the same institution were encouraged, to build a support mechanism (camaraderie) for the effort at the home institution. The participants included 22 males and 14 females. The majority of the participants were tenured or tenure track professors, including 10 Professors, 7 Associate Professors, 12 Assistant Professors, 6 program staff, and 1 graduate student. Based on Carnegie classifications of the 24 universities, 16 were public, 9 had participated in the elective classification on community engagement, and 6 of the universities were only undergraduate or very high undergraduate.[7] The participants represented a range of departments and programs (i.e. civil & environmental engineering = 7; biological / agricultural engineering = 3; mechanical engineering = 2; chemical engineering = 1; computer science = 1; construction management = 1), while many represented unique programs housed at a college-level (i.e. Engineering Education or Teaching Centers; Institute for Leadership; Engineering Design; Center for Technology and Innovation; staff representatives from Engineering Administration; etc. = 21). As part of the application, participants characterized their level of experience associated with LTS: novice = 6 (17%); intermediate = 24 (67%); advanced = 6 (17%). However, more objectively, the workshop organizers would re-classify some of the "intermediates" as advanced, giving 31% advanced (11 individuals).

The LTS programs led by workshop participants were in various lifecycle stages -- from development to plan new activities to well-established programs in need of some revision. For example, Kisaalita's international, interdisciplinary SL capstone design course at the University of Georgia has been running yearly since 2003.[35] By comparison, Catalano's redesigned senior capstone design course in bioengineering at Binghamton University was first offered with a SL model in the 2011/2012 academic year. Meanwhile, the integration of SL into a required year-long first year introduction to engineering course sequence at Walla Walla University was proposed.

Prior to the workshop, participants read various background materials[4,6,24,29]. During the first day of the 2-day workshops in Houghton, MI, and Boulder, CO, the participants self-rated 15 different characteristics for their LTS course or program on spectra (Table 3). These spectra were each scaled into four segments (e.g. none, low, medium, high). Mapping existing programs onto a unified framework like this begins to cultivate a comprehensive view of LTS within engineering. Understanding the range of current programs may help others in the creation and management of new programs.

Table 3. Learning through service program features self-evaluated by workshop participants

LTS Program Foci	Design	Management	Academic
Characteristics	1. Curricular positioning 2. Team size 3. Disciplines of students	4. Geographic context 5. Program size, students 6. Program size, faculty 7. Program size, staff 8. Duration 9. Interaction with community	10. Deliverables Assessment 11. Learning outcomes 12. Civic outcomes 13. Technical 14. Social/cultural

This rating activity was done by placing sticky notes with their program name onto a large (approximately 10-foot long), wall-mounted, axis scaled into four segments (Figure 2). Items were self-rated, and sometimes participants may have been poorly calibrated (through humility, inexperience, etc.). Participants placed their program sticky onto the axis when they felt ready, so there may or may not have been other ratings in place when they placed their sticky note. After the workshop, initial analysis counted the number of sticky notes in each quartile of the scale (with some programs placed on the boundary between two quadrants and therefore counted half for each). The ratings of all of the scales for each program were recorded on a spreadsheet. From this data, patterns and trends were analyzed including a correlation matrix.

During the two days, the workshop participants were guided through a process to create "blueprints" to examine and then build or revise their LTS course or program (Figure 3). The blueprint activity occurred after the spectra activity, and occurred in parallel with a number of worksheet activities that were generally conducted in small groups. The goal of the blueprint was to help each individual concisely and thoroughly consider important components of their LTS program. The content of each blueprint is summarized in Figure 5 below. Each participant was given a large "blank" blueprint, that contained initial questions for reflection and some examples, as shown in Figure 5. The content of each stage of the blueprint process was completed by participants for their particular LTS program over the two days of the workshop and then shared with others in a poster-style session. The intent of using the blueprint was to provide a framework that was flexible enough to allow for the development or improvements of a wide range of initiatives; to provide a consistent structure for participants to give each other feedback and compare work as they progressed; and to capture the results to share more broadly.

Figure 2. Depiction of the LTS spectral analysis for program/course characteristics

Figure 3. Workshop participants examined their LTS course or program using an organizational structure “blueprint”.

Results: LTS Programs Across the Spectra

Participants placed their LTS programs on various spectra of attributes, and these responses were converted to a 1 to 4 scale, depending on the “quartile” of the spectra into which the program was placed. One represented the “low” end of the scale and 4 the “highest” end of each scale. In some cases, a participant did not rate their program on one of the scales. In other cases, multiple representatives from the same program rated it in different locations. Therefore, the number of programs rated on each spectra varied, with a total of 32 to 33 ratings.

Program Design Spectra

Three elements related to program design were rated: curricular positioning, team size, and disciplinary involvement (Table 4). Eight (23%) programs were considered extracurricular (five of these were EWB programs), 53% were elective courses, and 24% were required courses. In some cases, the categorization isn’t obvious. One program rated itself as “elective/required”. For example, the First Year Engineering Projects (FYEP) course at the University of Colorado Boulder is required for some engineering majors but is an elective for other majors (Zarske et al. 2012). As another example, an elective course was being designed to integrate with EWB. In other cases, the course itself is required but the SL project within the course may be optional, i.e. capstone senior experience.

Student team sizes in these LTS programs ranged from one individual to large teams, with most programs mid-sized; 1%, 13%, 59%, and 26% LTS programs in each quartile. For example, FYEP teams are 4 to 5 students (rated as a 3) versus EPICS teams have been reported to range in size from 8 to 20 students (Coyle et al. 2005; rated in the workshop as a 3.5). There were no obvious differences in team size for extracurricular versus course-based programs.

Table 4. Number of LTS workshop programs rating in each quartile of the design spectra

	Lowest quartile	2nd quartile	3rd quartile	Highest quartile
Curricular positioning	Extracurricular 8 (23%)		Elective course 18.5 (53%)	Required course 8.5 (24%)
Team size	1 student 0.5 (1%)	4.5 (13%)	20 (59%)	Large 9 (26%)
Disciplinary involvement	Single discipline 3 (9%)	5.5 (16%)	9.5 (28%)	Muti-disciplinary 16 (47%)

The disciplinary breadth of the programs were also rated. Most programs were multi-disciplinary (rated as 4 on the scale), with 47% of the programs in the top quartile and only 9% of the LTS programs listed as single disciplines (rated as one on the scale); an additional 44% of programs were placed in the middle half of the scale. The required courses averaged lower disciplinary diversity (avg. 2.6) compared to elective courses (avg. 3.3) and extracurricular LTS programs (avg. 3.4). As an example of a self-rated "4" program, the Global Engineering Outreach elective course at BYU targets 30 engineering students from all disciplines and 10 sociology students, who will be divided into 5 teams (Randy Lewis). In contrast, disciplinary capstone design courses typically only enroll students from a single engineering major.

Program Management Spectra

Six program management characteristics were considered (Table 5). The program size in terms of the number of students were generally large (mode in largest quartile). The largest were elective courses (average 3.4) compared to required courses (average 2.9) and extracurricular programs (average 2.9).

Table 5. Number of LTS workshop programs rating in each quartile of the management spectra

	Lowest quartile	2nd quartile	3rd quartile	Highest quartile
Number of students	One Student 1 (3%)	9 (26%)	8 (23%)	Many Students 17 (49%)
Faculty involvement	No faculty 1 Faculty 1 (3%) 11.5 (34%)	7.5 (22%)	7 (21%)	Many Faculty 7 (21%)
Staff support	No Staff 22 (65%)	5 (15%)	6 (18%)	Many Staff 1 (3%)
Geographic context	Local 14.5 (43%)	3.5 (10%)	3 (9%)	International 13 (38%)
Duration	Days 0	11 (32%)	9 (26%)	Years 14 (41%)
Community Interaction	Minimal/indirect 0	9 (26%)	14 (40%)	Immersive 12 (34%)

Faculty involvement was most commonly single (34% LTS programs) but also ranged to large (21% in the top quartile). Extracurricular programs involved far fewer faculty (average 1.3) than required or elective courses (average 2.4 and 2.6, respectively). The vast majority of the LTS programs reported no staff support (65% LTS programs in the bottom quartile); only a single program reported staff involvement in the highest quartile. The highest staff support was reported for elective courses (average 1.9) compared to required courses (average 1.3) and extracurricular programs (average 1.1).

For geographic context there was nearly an even split between local and international projects, and two programs were split indicating that they included some projects in both local and international locations. Interestingly, 8 of the required courses used local projects, and only 1 required course was 2 on the local to international scale. By comparison, the elective courses ranged from local to international and every category between. The extracurricular activities were predominantly international (n=6) rather than local (n=2).

Fourteen programs (41%) were placed at the high end of the time scale indicating a duration of years (i.e. EPICS), and no programs were only of a duration of days. Programs in the middle of the duration scale were in the weeks to semester range. Self-calibration may be impacting these results. For example, iDesign is a full 12-month experience and was rated as a 3, along with 2-semester capstone courses. The required courses had on average the lowest duration (avg. 2.7) compared to elective courses (avg. 3.2) and extracurricular programs (avg. 3.3).

No programs reported minimal or indirect interactions with their community partner; 34% of programs were in the top quartile reporting immersive interactions. However, community interaction was lower, on average, in required courses (avg. 2.6) compared to elective courses (avg. 3.2) and extracurricular programs (avg. 3.3).

Academic Spectra

Six of the characteristics were primarily academic in nature, and include deliverables, assessment, learning outcomes, civic outcomes, technical content, and social content (Table 6). Most programs indicated that they included substantial and many deliverables, with only one EWB program in the bottom quarter of the spectrum. Assessment across the programs was more diverse and nearly even across the range of the spectrum. Student learning outcomes tended to 'clear and rigorous', with 13%, 16%, 30%, and 41% of the programs in the quartiles from none to clear and rigorous. By comparison, civic outcomes were nearly evenly distributed in all four quartiles of the scale, which ranged from only experiential to experiential with deep reflection.

Table 6. Number of the LTS workshop programs rating in each quartile of the academic spectra

Spectra	Lowest quartile	2nd quartile	3rd quartile	Highest quartile
Deliverables	None 1 (3%)	3 (9%)	13 (37%)	Substantial & Many 18 (51%)
Assessment	Little 8 (23%)	8.5 (24%)	8 (23%)	Rigorous & Aligned 9.5 (27%)
Learning Outcomes	None 4.5 (13%)	5.5 (16%)	10.5 (30%)	Clear, rigorous 14.5 (41%)
Civic Outcomes	Purely experiential 9 (26%)	9.5 (27%)	8 (23%)	Reflective, civic outcomes assessed 8.5 (24%)
Technical content	None 0	9 (26%)	15 (44%)	Deep & Complex 10 (29%)
Social/cultural content	None 2.5 (7%)	10 (29%)	9.5 (27%)	Deep & Complex 13 (37%)

The technical content of the LTS programs were predominantly in the third highest quartile (average 3.0), while social/cultural content had a broader range and averaged a little lower (2.9).

Not surprisingly, learning outcomes were the lowest in the extracurricular programs (avg. 1.8) compared to elective courses (avg. 3.3) and required courses (avg. 3.5). Deliverables were also more rigorous in the required and elective courses (avg. 3.5 and 3.5) compared to the extracurricular programs (avg. 2.9). The required courses had, on average, more modest social/cultural content (avg. 2.4) than either elective courses (avg. 3.0) or extracurricular programs (avg. 3.4). Civic outcomes were also lower in required courses (avg. 2.1) compared to extracurricular (avg. 2.3) and elective courses (avg. 2.7). Technical content was the highest in elective courses (3.2) compared to required courses (2.9) and extracurricular programs (2.8).

Spectra Pattern Analysis

Using correlation analysis, some rough relationships were evident, a few significant (see Figure 4). The spectrum of extracurricular activity through required courses was negatively correlated with geography (so extracurricular activities were most often international while required courses were most often local projects; correlation coefficient -0.55; $p<0.01$). The spectrum of extracurricular activity through required courses was also somewhat negatively correlated with social / cultural content (correlation coefficient -0.38; $p=0.02$), where the extracurricular activities tended to place a greater emphasis on social/cultural context. Other weak negative correlations between extracurricular through required courses were: duration (longer for extracurricular and shorter for required courses; -0.28; $p=0.10$), community interactions (more immersive with extracurricular; -0.28; $p=0.11$), and multidisciplinary (wider array of disciplines in extracurricular; -0.27; $p=0.13$). The spectrum of extracurricular activity through required courses was positively correlated to learning outcomes (correlation coefficient 0.53; $p<0.01$); there was a weaker positive correlation with amount of faculty involvement (correlation coefficient 0.33; $p=0.06$) and rigor of assessment (0.31; $p=0.07$). This is logical given that required courses have rigorous learning outcomes that must be assessed for a grade, and are taught by faculty with an appropriate level of support.

Other correlations that were statistically significant (p values for Pearson test <0.05) were also found. Social/cultural content was positively correlated to community interaction, civic outcomes, geography, and duration. Thus, not surprisingly more extended interactions with community partners, with required reflection by students provides a means of achieving learning outcomes related to social/cultural content. In addition, an international context can draw additional attention to these issues that might otherwise be less evident to students working within their own community and culture. Civic outcomes were positively correlated with social/cultural content, staff support, and community interaction. Staff support was a somewhat unexpected finding. However, staff support may indicate broader or long-term support of the LTS program overall, which helps facilitate more stable and meaningful relationships with community partners. Assessment rigor was positively correlated with faculty involvement, learning outcomes and deliverables, but negatively correlated with geography. Learning outcomes were also positively correlated with faculty involvement.

Figure 4. Correlation matrix between spectra; correlation values shown; bright yellow highlight and bold text indicates $p<0.05$; light yellow highlight indicates a weaker correlation, $0.10 < p < 0.05$

	course	teams	disciplines	# students	faculty involvement	staff support	geography	duration	community interaction	deliverables	assessment	technical content	social/ cultural content	learning outcomes	civic outcomes
course	1	0.10	-0.27	0.02	0.34	0.12	**-0.55**	-0.29	-0.28	0.24	0.31	0.00	**-0.38**	**0.53**	-0.03
teams	0.10	1	0.03	**0.35**	0.21	0.09	-0.03	0.15	0.05	-0.04	-0.10	**0.40**	-0.04	0.25	0.19
disciplines	-0.27	0.03	1	0.26	0.18	0.05	0.04	**0.43**	0.26	0.12	0.15	0.02	0.24	-0.05	-0.00
# students	0.02	**0.35**	0.26	1	0.20	0.28	-0.08	0.06	0.31	-0.25	0.25	0.19	0.09	0.14	0.01
Faculty involvement	0.34	0.21	0.18	0.20	1	0.24	-0.01	0.25	-0.06	0.03	**0.47**	0.31	-0.21	**0.45**	0.02
staff support	0.12	0.09	0.05	0.28	0.24	1	0.01	0.17	0.17	-0.00	0.30	0.01	0.02	0.04	**0.41**
geography	**-0.55**	-0.03	0.04	-0.08	-0.01	0.01	1	**0.51**	0.33	-0.26	**-0.44**	0.10	**0.48**	-0.29	0.23
duration	-0.29	0.15	**0.43**	0.06	0.25	0.17	**0.51**	1	**0.39**	-0.07	-0.13	0.15	**0.38**	-0.08	0.09
Community interaction	-0.28	0.05	0.26	0.31	-0.06	0.17	0.33	**0.39**	1	0.07	-0.03	0.11	**0.68**	-0.09	**0.34**
deliverables	0.24	-0.04	0.12	-0.25	0.03	-0.00	-0.26	-0.07	0.07	1	**0.37**	0.22	0.01	0.30	0.05
assessment	0.31	-0.10	0.15	0.25	**0.47**	0.30	**-0.44**	-0.13	-0.03	**0.37**	1	-0.08	-0.27	**0.42**	0.03
Technical content	0.00	**0.40**	0.02	0.19	0.31	0.01	0.10	0.15	0.11	0.22	-0.08	1	0.11	0.14	-0.16
social/cultural content	**-0.38**	-0.04	0.24	0.09	-0.21	0.02	**0.48**	**0.38**	**0.68**	0.01	-0.27	0.11	1	-0.17	**0.42**
Learning outcomes	**0.53**	0.25	-0.05	0.14	**0.45**	0.04	-0.29	-0.08	-0.09	0.30	**0.42**	0.14	-0.17	1	0.25
Civic outcomes	-0.03	0.19	-0.00	0.01	0.02	**0.41**	0.23	0.09	**0.34**	0.05	0.03	-0.16	**0.42**	0.25	1

Results: Blueprints

The content of the blueprints generated by the workshop participants were analyzed to determine any common themes or identify unique elements. There were 34 different blueprints from the two workshops; a group of three individuals from the same program created a shared blueprint.

The blueprint, as a program development tool, begins with stakeholder analysis. Across the 34 blueprints, the number of different stakeholders identified ranged from 3 to 10, with a median of 5 stakeholders. All of the blueprints included students as a stakeholder. These were sometimes identified more specifically, such as undergraduate students or graduate civil engineering students.

Based on the definition of LTS, it was expected that all blueprints would also list the community partner as a stakeholder. Eighty-eight percent of the blueprints included community, community partner, and/or community members as a stakeholder (30 of 34). Of the four that did not include some form of "community" as a stakeholder, three were elective courses and one was an extracurricular LTS program. One LTS course seemed to indicate that a local university (not the site of the LTS program) was their partner. Another curricular LTS program listed specific types of community partners, including civic organizations, churches, schools [K-12], and NGO partners. The extracurricular LTS program seemed to have used either industry or owners (private / commercial) in lieu of a community partner. Only one blueprint seemed to truly have included no obvious community – this was an elective course on green building systems. Interestingly, the worksheets from the same program listed "address community needs" as a community impact from the LTS program, and indicated that "tangible outcomes" for the community was satisfied by the program at a rating of 10.

The third most widely cited type of stakeholder was some combination of the university, administration / administrators, college, and/or department. Eighty-two percent of the blueprints included one or more of these stakeholders. University was the most widely used version of this, present in 21 of the 34 blueprints. Some blueprints were very specific; one blueprint listed deans, provost, chancellor, and president as stakeholders. The six blueprints without a university-type stakeholder listed all represented elective LTS courses.

Faculty and/or myself were listed as stakeholders on 65% of the blueprints. Blueprints without a faculty stakeholder evident spanned the range of required courses with an LTS component (n=3), elective courses with an LTS components (n=5), and extracurricular LTS programs (n=4). Other common stakeholders were non-governmental organizations (NGOs) 29%, donors / financial contributors 18%, alumni 18%, industry / businesses / industrial advisors 12%, and program staff 12%. Other less commonly cited stakeholders were parents, K-12 students, K-12 teachers, LTS program coordinator, design reviewers, mentors, student affairs, local / state agencies, future students, clients, public, etc.

Other areas of the program blueprints are currently being analyzed for patterns.

Figure 5. Learning Through Service Program Model Blueprint with sample leading questions in each of the nine compartments

<table>
<tr><td colspan="2">Program Name:</td><td colspan="2">Designed by:</td><td>Date drafted:</td></tr>
<tr>
<td rowspan="2">5. Partnerships
Who are your key partners?
Which key activities do partners perform?
Which key resources do you acquire from partners?

Examples:
Fundraising
Marketing
Evaluation
Acquisition of needed resources
Facilitation of institutional requirements</td>
<td>6. Key Activities
What key activities do your value propositions requires?
Your channels?
Your stakeholder relations?

Examples:
Information session
Direct engagement with stakeholders
Research / education</td>
<td rowspan="2">2. Value Proposition
What value do you deliver to each stakeholder?
Which of your stakeholders' problems are you helping to solve?
What services or products are you offering to each stakeholder segment?
Which stakeholder needs are you satisfying?

Examples:
Practical assistance toward a more sustainable community
Community-based design
Infrastructure development
Professional development
Student retention
Enhanced learning</td>
<td>3. Relationships
What type of relationship do each of your stakeholders expect you to maintain with them?
Which relationships have you established?
How are they integrated with the rest of your program model?
How costly are they (in terms of value / impact)?</td>
<td rowspan="2">1. Stakeholders
For whom are you creating value?
Who are your most important stakeholders?

Examples:
Students
Community members
Colleagues
Alumni
Administrators
NGOs
Businesses
Government
University
Public</td>
</tr>
<tr>
<td>7. Resources
What key resources do your value propositions need?
Your channels?
Your stakeholder relations?

Examples: equipment, data, human resources, financial, trust</td>
<td>4. Channels
How do your stakeholders want to be reached?
How are you reaching them now?
How are your channels integrated? With stakeholders routines?
Which are most effective?</td>
</tr>
<tr>
<td colspan="3">8. Value Streams: Costs and Outlays
What are the most important costs inherent in your program model?
Which key activities are most expensive? In terms of what value?
Which key resources are most expesnive? In terms of what value?
Examples:
fixed costs like tuition;
variable costs like time, energy, enthusiasm
Economies of program scale, program scope
Activities that place value at risk</td>
<td colspan="2">9. Value Streams: Returns
For what value are your stakeholders willing to "pay"?
For what do they currently contribute / pay?
In what ways will your stakeholders return value? In what forms?
How are they currently contributing? How would they prefer to contribute?
How much does each value stream contribute to the overall success of your program?</td>
</tr>
</table>

Summary and Further Work

The present work has begun to characterize the types of LTS efforts and types of LTS models that exist in engineering programs. It is hoped that as the diversity of models becomes more widely recognized, more faculty and programs engaging with LTS will grow. A shared model for LTS programs may also facilitate future assessment efforts, to help improve understanding of best practices and areas where further study and research would be beneficial.

Many LTS programs have emerged somewhat more organically and through trial-and-error processes. Often, we are re-creating the wheel. Designing these initiatives by first evaluating the initiative's potential and limitations with the characteristics outlined by McCahan et al.[24] and following a common process for design (the blue print) may help faculty to compare and more easily share their work. These characteristics will often emerge from a combination of necessity (i.e. a required course or not; availability of staff support of not) and attributes that meet the desired goals of the program. A post-workshop evaluation assessing the value of using the characteristics spectra and following the currently proposed blueprint will help to determine whether these tools help to create stronger program design.

An expanded analysis of existing LTS programs and LTS programs that have been discontinued may help to identify best practices associated with particular LTS goals. At present, there is not an obvious "best model". Faculty may be interested in what program attributes tend to correlate with particular learning outcomes for students, benefits for community partners, and faculty/university goals. Some attributes lend themselves more readily to particular types of outcomes. "Start small rather than not at all" (paraphrased from John Duffy, UMass-Lowell) is an approach that has often been adopted. The benefits and gains of a good LTS program may outweigh the concerns about not designing and offering a "perfect" program. Irrespective of constrained resources, thoughtful planning and design of LTS programs should lead to improved outcomes for all stakeholders.

Assessment was found to be a particularly challenging part of the workshop. Most LTS assessment efforts to date have focused on student learning outcomes. But some desired outcomes from LTS are very difficult to measure (i.e. cultural competency of students). Many individual LTS courses or programs are also small, which limits the ability to measure statistically significant gains compared to student learning through traditional or alternative teaching approaches. Assessment of community, faculty, and university outcomes is much more rare. If the body of LTS practitioners can agree to share some assessment methods and metrics, more evidence for the benefits and limitations of different varieties of LTS may be gained.

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