

# Service-Learning Assessment: Sustainability Competencies in Construction Education

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**Abstract:** Under the umbrella of a departmental initiative termed CM Cares, faculty from Colorado State University have developed a service-learning course to teach and implement concepts related to sustainability in construction education. The course has met with significant success and received recognition from community partners, elementary to graduate students, faculty members, and department and university administration. Beyond the positive response to experiential learning and community action, this paper uses data from the second course offering to assess the course's effectiveness for teaching sustainability competencies. The writers implemented multiple techniques to collect data and assess perceived learning with regard to sustainability competencies. Techniques included surveys, reflection essays, and concept maps. Overall findings were mixed but suggest that significant learning about sustainability can occur using service-learning as a teaching technique in construction education despite (and perhaps because) students question the value of what they have learned and how to implement it. Specifically, students report increased appreciation of the challenges as well as benefits related to sustainability. The contribution of this paper is the successful application of community-based research constructs to a service-learning course case study to assess its effectiveness at developing key sustainability competencies. By documenting a successful case study, this paper supports future efforts to integrate sustainability into construction education, encourages further and similar course development, and provides a model for future service-learning assessment research. DOI: 10.1061/(ASCE)CO.1943-7862.0000769. © 2013 American Society of Civil Engineers.

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## Introduction

Service-learning is a pedagogy that promotes educational experiences in which students participate in and reflect upon organized activities that meet identified community needs to gain further understanding of concepts being taught and a broader understanding of the overall discipline (Hatcher and Bringle 1997). Students who participate in service-learning develop more sophisticated metacognitive abilities, better strategic planning and task-analysis skills, better ability to discriminate useful from insignificant information, and better understanding of client needs and constraints (Lemons et al. 2011). Research findings and educational practice demonstrate that service-learning is effective and well-suited for educating design, building, engineering, and construction students due to the applied nature of these disciplines, many of which already require experiential education in the form of internship, practicums, or cooperative service to graduate (McCrary et al. 2007). Al-Khafaji and Morse (2006) suggest that service-learning is a particularly effective strategy for addressing the pressing need in engineering-related disciplines to better incorporate sustainability into curricula. By cultivating a sense of civic responsibility, engagement, and commitment to community (Astin and Sax 1998;

Astin et al. 1999) service-learning may promote a greater sense of stewardship towards local and global environments.

Academia's shortcomings in teaching sustainability concepts appear endemic, and may represent a fundamental and systemic problem in higher education in the fields of engineering and construction. Research shows that engineering and related education is largely deficient in teaching students basic principles of sustainable development (Azapagic et al. 2005). A fundamental concern for many university students may be the scale of the issues involved. Students may feel helpless in the face of sustainability challenges on a global scale. In a traditional classroom, students may conclude that the impact of their efforts will be insignificant. Research suggests service-learning may provide an educational platform for teaching ethics related to sustainable development and social sustainability, as well as basic principles of sustainable design (Al-Khafaji and Morse 2006; Pritchard 2000; Valdes-Vasquez and Klotz 2010).

Community engagement and partnership is gaining recognition as a new and important dimension of academic learning (Gelmon et al. 2006). Service-learning directly promotes engagement and collaboration. Hands-on construction projects offer significant opportunities for collaborative learning, critical to construction practice today (Trans et al. 2012). A major challenge to more widespread acceptance and inclusion of service-learning courses throughout higher education, however, is the lack of traditional assessment techniques to provide evidence of learning outcomes. In general, learning outcomes are commonly accepted in evaluations of education and training activities (Bloom et al. 1971). However, academic programs currently struggle to document the impact of service-learning courses as necessary to verify learning, support course improvement, and justify accreditation. The term competency is frequently used in the construction education literature to describe required learning outcomes, and is defined as

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“a combination of skills, abilities, and knowledge needed to perform a specific task” (Jones and Voorhees 2002).

In previous research (Clevenger and Ozbek 2013), the writers outlined the structure and learning outcomes of an innovative service-learning course focused on sustainability. In that previous research, the writers documented how their course enables students to build small-scale, real-world sustainable projects while accomplishing the following goals: (1) engage at-risk teens within the local community, and (2) empower construction management university students to be leaders, stewards, and mentors. The course structure consists of three five-week phases, as follows: (1) preconstruction, (2) construction, and (3) review. The course follows a design/teach/build model. Preliminary assessment of the pilot offering suggested that such a course could serve as an academic model for incorporating concepts related to social sustainability into construction education (Clevenger and Ozbek 2013). This research builds upon and extends such previous research in the following ways: (1) it focuses on assessment of successful integration of sustainability competencies rather than the unique model of the course, (2) it implements survey instruments for service-learning assessment previously established in the service-learning literature, and (3) it analyzes data collected from a second, independent offering of the course.

Researchers have begun to develop, identify, and delineate key sustainability competencies. Wiek et al. (2011) performed a broad literature review to identify categories of competencies related to sustainability. They identified five types of competencies, as follows: (1) systems thinking, (2) anticipatory, (3) normative, (4) strategic, and (5) interpersonal. Frisk and Larson (2011) note that educating for sustainability requires alternative forms of knowledge such as procedural, effectiveness, and social knowledge. They further refine key sustainability competencies to include the following:

- Systems thinking and an understanding of interconnectedness;
- Long-term, foresighted thinking;
- Stakeholder engagement and group collaboration; and
- Action-orientation and change-agent skills.

The service-learning model, based on experiential education, may be particularly well-suited to promote such competencies.

## Purpose of the Research

The purpose of the research reported in this paper is to assess the effectiveness of the case study service-learning course, offered by the writers in the Department of Construction Management at Colorado State University during spring 2012, to increase student sustainability competencies.

## Methodology

To assess learning with regard to sustainability competencies the writers applied a framework of community-based research learning outcomes (Lichtenstein et al. 2011). The research reported in this paper is based on data collected during a single course offering of leadership of sustainable community projects during spring 2012. Research methods used in the assessment include thematic analysis of surveys, student reflections, and concept maps. These methods were used to collect data regarding the students' perceived learning outcomes.

## Surveys

Surveys are a traditional and common assessment technique due in large part to ease of analysis. In the research reported in this paper,

surveys were used to describe and assess changes in student perspective and attitudes relative to their experiences in the service-learning course using a five-point Likert scale (strongly disagree = 1 to strongly agree = 5). The survey instrument administered was adapted from the community-based research (CBR) course survey developed as part of an effort to develop a national CBR course assessment survey (Lichtenstein et al. 2011). Results were broken down and analyzed in accordance with the subsequent categories identified by Lichtenstein et al. (2011) as codifying student learning outcomes for community-based research (Table 1).

Due to the small sample size (six graduate students, yet 100% of class participants) no statistical analysis was performed. Results presented in the Results section represent class averages and were analyzed in accordance with general patterns. Documentation of student perceptions is important because it can inform future course offerings. There are generally limitations regarding the use of surveys to assess service-learning. These include the following (Holland et al. 2006): (1) inability to capture student voice, (2) personal stories, and (3) complex multidimensional experiences. In addition, as may be the case with the research reported in this paper, surveys can be given too close to the end of the personal experience to allow for proper gestation of learning. During the research reported in this paper, survey results were collected during the second and last class periods of the semester. Given the relevant limitations, additional methods were also used to collect data regarding students' perceived learning outcomes as discussed next.

## Reflections and Short Answers

Written and oral reflection is a core component of any service-learning course, in which learning is structured around the cyclical exchange of experience and reflection (Eyler and Giles 1999). Such activity allows students to critically examine and place their experiences within an educational context. Moreover, reflection emphasizes the role of the student as an active rather than passive learner, encouraging students to be responsible for their own learning. During spring 2012 each student wrote three reflections papers, i.e., one during each of the course phases as described next. In addition, they each responded to several short-answer questions at the end of the semester. Their statements and expressed opinions were independently thematically analyzed by a graduate student and two faculty members to triangulate findings.

## Concept Maps

Concept maps were used as a final research method. Joseph Novak developed concept maps as a learning tool and evaluation method

**Table 1.** Community-Based Research Learning Outcome Survey Constructs and Definitions

Construct	Definition
Academic skills	Cognitive skills related to academic learning
Educational experience	Affective outcomes that enhance the overall college experience, including finding one's passion, enhancing one's interest in one's major, and clarifying a career path
Civic engagement	Cognitive, affective, and behavioral outcomes related to community participation
Professional skills	Skills, behaviors, and attitudes that enhance efficacy in the workplace
Personal growth	Affective outcomes related to understanding oneself, including personal insights and transformation

Note: Reprinted from Lichtenstein et al. (2011), with permission from the University of Georgia.

in the 1970s (Novak and Gowin 1984). They provide a graphical representational technique that can be used to organize and represent knowledge. Previous research has identified concept maps as valuable tools in evaluating learning related to sustainable development (Clevenger and Ozbek 2013; Lourdel et al. 2007). For the research reported in this paper, results were thematically analyzed by two faculty and concepts were tallied in accordance with the number of appearances for the identified themes. As such, results are primarily qualitative, based on concepts in addition to concept associations developed and documented by students in their maps.

## Case Study

The case study is based on a course offering of “Leadership of Sustainable Community Projects” in spring 2012. The course is a service-learning course for graduate students in construction management that operates in partnership with a local alternative high school building-trades shop class. In the course, graduate and high school students collaborate to build small-scale, sustainable construction projects implementing a teach/build/learn course structure (Clevenger and Ozbek 2013). In the second course offering, students built 12 xylophone music stands for a local elementary school (Fig. 1). Two of these stands, at the suggestion of the graduate students, were constructed to be accessible to individuals in wheelchairs. The course is part of a larger emerging initiative in the Department of Construction Management (CM) termed CM Cares, which involves and connects students and industry members in community-service projects. Community members self-identify need by applying to the CM Cares project call. The music stand project was selected by a committee from the applicant pool submitted by the community to the CM Cares website. This is a competitive process and currently the CM Department is not able to fill all project requests.

As part of the class, the graduate students detail and document the construction project in a curriculum tool, in this case, entitled “Constructing a Musical Instrument Stand Utilizing Sustainable Materials: Lesson Plans and Building Instructions” (Fig. 2). The curriculum tool is intended to support project replication by future high school students seeking to build a sustainable construction project. Even on a small-scale such a project represents many



Fig. 1. Completed music stand with xylophone

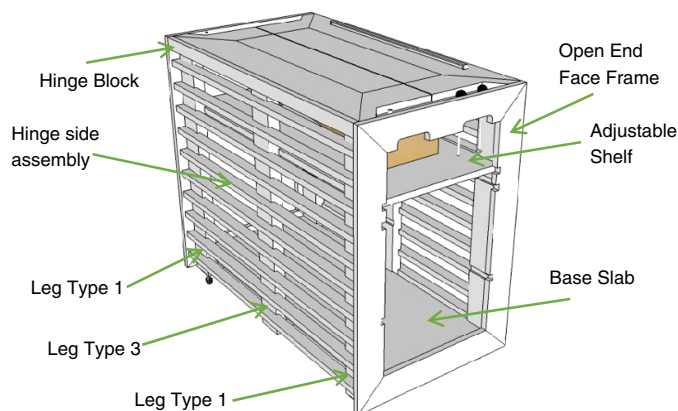


Fig. 2. Diagram detailing music stand construction figure in curriculum tool

facets of the triple-bottom-line, consisting of the three pillars of sustainability, as follows: (1) environmental, (2) economic, and (3) social. However, within the one semester time-frame it is not possible to address such concepts across a project’s entire lifecycle. Specifically, the operation and maintenance as well as deconstruction phases are not implemented. Interestingly, and as discussed by the students, such a course limitation is illustrative of a fundamental challenge for sustainability related to the built environment, i.e., the split incentives that exist between construction, operation, and end-of-life phases that frequently involve independent stakeholders and decision makers. Examples of concepts concerning the three pillars of sustainability as related to design and construction that are highlighted in the curriculum tool (in the students’ own words, as shown within quotation marks) and taught to the high school students include the subsequent examples.

## Environmental

Example concepts from an environmental perspective include the following:

- Salvaged wood. All of the wood used for the stands was salvaged with the exception of the bottoms and lids, which were made from furniture-grade plywood and beetle-kill pine, respectively. “Salvaged materials can be found through material recovery businesses or as part of a salvage project in your area.” “By incorporating salvaged materials, we have diverted the material from landfills.” “Using salvaged lumber reduces the number of trees cut down preserving a valuable natural resource while using less energy and creating less waste than turning trees into new lumber.”
- Beetle-kill pine. In recent warm years the pine beetle has been responsible for premature decimation of much of Colorado’s alpine forests. “Pine is softwood that is a waste product and is well suited for building components such as furniture and millwork since its wood properties were not compromised by the deadly pine beetle.” In addition, the wood has a distinctive and beautiful blue discoloring once treated. “It is important to support sustainable methods in forest management.” “The Forestry Stewardship Council (FSC) is an association that strives to enhance these methods. While the Colorado forests are not FSC certified, it is important to understand their goals.”
- Natural stain and finishes. The wood was treated using a home-made coffee-based stain. “Some stains are not only harmful to the environment, but also have adverse health effects on the



workers during application. Some stains elements have the potential to outgas for many years after the stain has dried.”

- Reclaimed screws. Students used reclaimed screws as fasteners.
- Reduced waste. Project dimensions were optimized to reduce material waste during construction. In addition, high school students were taught to “recheck measurements prior to making a cut. This will help minimize wasted materials.”

## Economic

Example concepts from an economic perspective include the following:

- Salvaged materials. Salvaged materials were used whenever possible. “Reuse of salvaged in lieu of new/virgin materials significantly reduced material costs.” “It is possible to find used casters rather than buy new ones for this project. Used casters may be cheaper, but it may be difficult to find adjustable casters.”
- Beetle-kill pine. “By using beetle-kill pine, the material is produced in Colorado, supporting the local economy.”
- Additional rework. “Reclaimed lumber may require additional prep work or milling in order to make a clean and straight piece suitable for use.” “Salvaged lumber that requires a great deal of extra time and labor to prepare may not be as sustainable as using a material that provides better results and is easier to work with. The choice to use salvaged lumber over new material has to be considered.”
- Embodied energy. “Using salvaged lumber... [preserves] a valuable natural resource while using less energy...” Prolonging end of life by using a salvaged material more effectively leverages the embodied energy of the existing material.

## Social

Example concepts from a social perspective include the following:

- Beetle-kill pine. “More than 3 million acres of trees in Colorado forests are estimated to have been destroyed by the pine beetle. The mass amount of dead trees poses a significant fire danger to the forests.”
- Safety. “Ensure that all students and instructors are knowledgeable about the safety practices and procedures associated with the use of any power tools, equipment, and products.”
- Equity. “Americans with Disabilities Act guidelines were followed as closely as possible in the two handicap accessible stands constructed. It is critical that all students be able to use these stands.”
- Occupant satisfaction. “Children will be the primary users of these music stands. Ease of use is an important consideration.”
- Health and environmental quality. “What issues need to be considered in relation to the health impacts the materials and finishes may have on the young users?”

The course strives to teach about sustainability by providing a thoughtful, first-hand experience of the teamwork and challenges faced in sustainable construction practice. Stated learning objectives for the course include to the following:

- Demonstrate an ability to make decisions that relate to sustainable project delivery;
- Apply sustainable design and construction principles to all phases of real-world construction;
- Explain sustainable design and construction principles to individuals from diverse backgrounds;
- Recognize community need and identify opportunities and challenges of addressing such need by practicing integrated project delivery as a community service project; and

- Promote local youth interest in sustainable practices and encourage and enable these students to become productive and contributing members of society.

Achievement of these objectives is sought through the reciprocal process of service and learning in three discrete phases of the course, as follows: (1) preconstruction, (2) construction, and (3) review. A detailed discussion on what is accomplished in each phase is presented by Clevenger and Ozbek (2013).

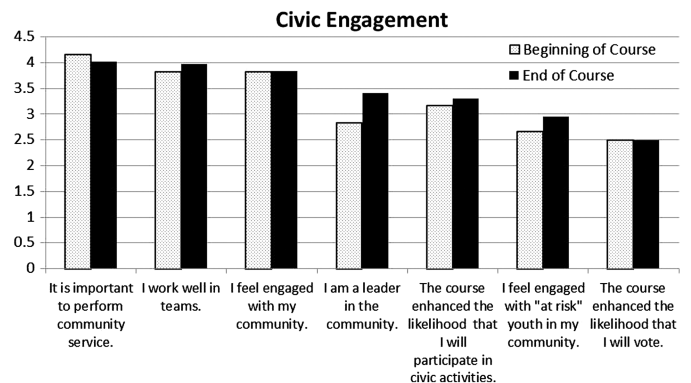
## Results

The subsequent section presents the results of three assessment strategies intended to evaluate student perception regarding learning outcomes.

### Surveys: Overview

Figs. 3–7 present survey results based on the average response of the six graduate participants in the course. The survey response rate was 100%. Survey questions were adapted from the community-based research course survey (Lichtenstein et al. 2011). Results are presented in accordance with the constructs and definitions developed by Lichtenstein et al. (2011) for this survey. Fig. 3 compares self-assessment statements made by the students before and after participating in the course with regard to civic engagement. Figs. 4–7 compare the students’ assessment of learning and other course activities for the sustainability service-learning course compared with a previous-best course, as individually selected by each student based on personal experience and opinion. The writers acknowledge that data representing previous-best course provides a varied baseline. However, the decision to compare the course with a previous-best course was made to set a high bar for comparison and to address some of the well-documented challenges of unique service-learning courses. Specifically, one assessment challenge noted in the literature is the insufficient passage of time prior to assessment due to the long-term versus short-term impact of service-learning. The hope is that a relative comparison with the best course may partially mitigate some of the difficulty of assessing short-term impact by putting the course in context of a specific (i.e., previous-best) course.

A comparative analysis using such a high benchmark provides an important context to assess the overall service-learning educational experience. In all cases, a score that is more than 2.5 demonstrates student agreement with the statement, with 5.0



**Fig. 3.** Student survey results regarding attitudes towards civic engagement prior and subsequent to completion of the course

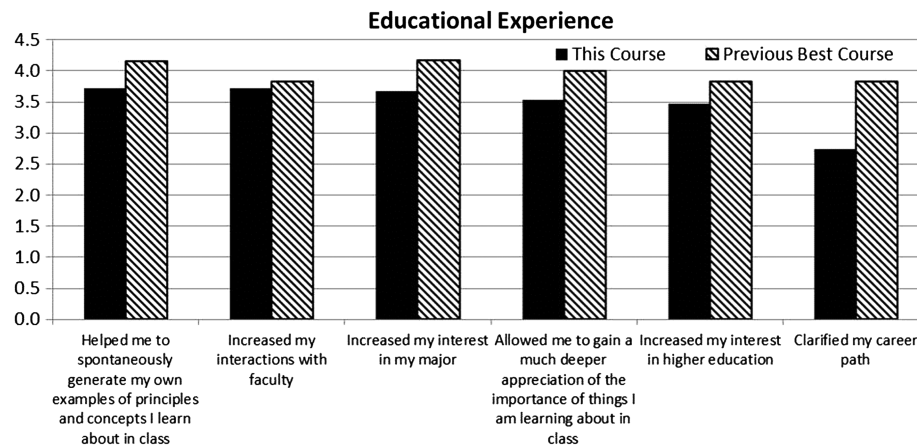


Fig. 4. Student survey results regarding educational experience of the course compared with previous-best course

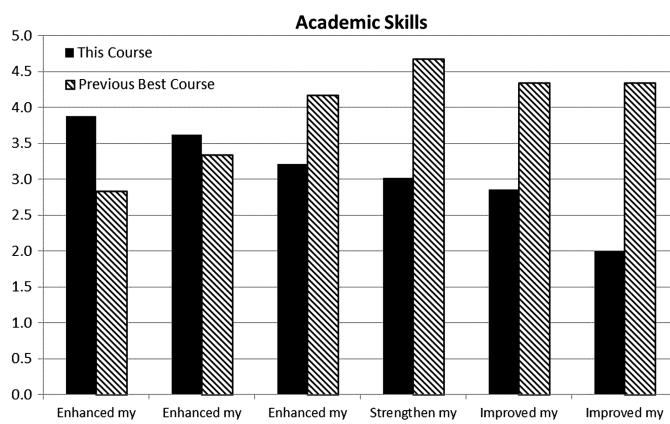


Fig. 5. Student survey results regarding academic skills provided by the course compared with previous-best course

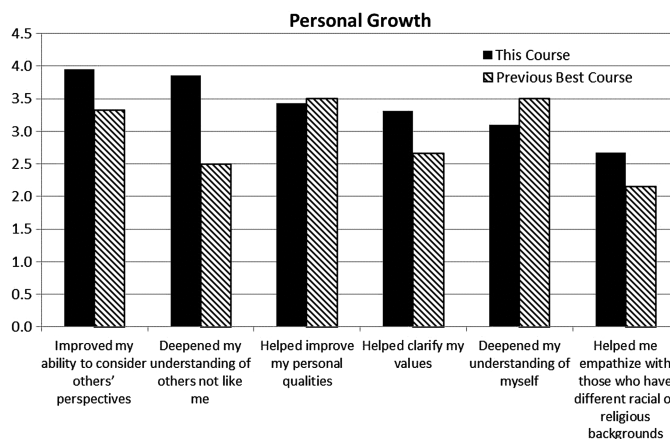


Fig. 6. Student survey results regarding personal growth that occurred during the course compared with previous-best course

providing full agreement. As such, the writers note that the only statements with which the students disagreed in the survey were the following:

- The sustainability service-learning course improved their research skills;

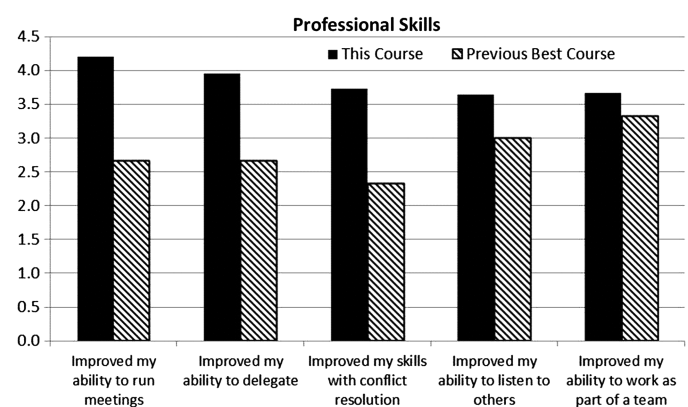


Fig. 7. Student survey results regarding professional skills gained during the course compared with previous-best course

- Their previous best course helped them empathize with those who have different racial or religious backgrounds; and
- Their previous best course helped them with their conflict-resolution skills.

Figs. 4–7 illustrate survey findings across community-based research constructs.

Findings from survey results support the subsequent observations relative to the community-based research learning outcomes. In all cases, results are based on student self-reported perceptions.

### Surveys: Civic Engagement

At the end of the sustainability service-learning course, students generally feel more engaged with their community and that they are better community leaders. The one exception to this sentiment occurred in their response to the statement, “It is important to perform community service.” As discussed in the conclusions, this is noteworthy since it supports the writers’ previous research findings in which student participants in a prior course offering also expressed a decreased level of importance for performing community service after taking the course (Clevenger and Ozbek 2013).

### Surveys: Educational Experience

Whereas the sustainability service-learning course did not meet the level of overall educational experience that was provided by the

students' previous best courses, it still made a strong positive impact in all areas except clarifying a career path. Presumably, the career path of a construction management graduate student taking a service-learning course is fairly set. However, it may be inferred from this answer that the students are not more likely to champion a community-based construction career path (for example, Habitat for Humanity or Peace Corp) after taking this class.

### **Surveys: Academic Skills**

The sustainability service-learning course provided mixed results in accordance with the academic skills it supported. It significantly exceeded previous best courses in providing skills related to local and social issues. It did not meet the level of skill provided by their previous best course with regard to academic content, analytical, or writing skills. Nevertheless, the sustainability service-learning course made a positive impact in all of these areas with the notable exception of research, in which the graduate students felt the course did not improve their skills.

### **Surveys: Personal Growth**

The sustainability service-learning course generally provided more opportunity for personal growth than any previous-best course. The courses was particularly illuminating with regard to understanding differences between individuals and clarifying personal values. However, the students did not feel that the course provided more opportunity to understand themselves.

### **Surveys: Professional Skills**

The sustainability service-learning course exceeded the level of professional skills learned across all related categories compared with any previous best course. Whereas it is not surprising that participation in a hands-on course in which students actually build a small-scale project provides a high level of professional skill, it is notable that the reported skills all involve teamwork and the ability to lead or work with others, and all noted significant improvement.

### **Reflections and Short Answer Questions: Overview**

The subsequent results summarize the dominant themes expressed by students in their written reflections and short answers to questions as assigned during each of the three phases of the sustainability service-learning course, as follows: (1) preconstruction, (2) construction, and (3) review.

#### **Reflections and Short-Answer Questions: Preconstruction**

In written reflection during the preconstruction phase of the class, students expressed the following themes:

- Excitement about the opportunity to teach sustainability to high school students;
- Importance of teaching issues surrounding sustainability and preparedness to teach about sustainability;
- Interest in being positive role models and motivating others (they identified this as more important than actual project construction);
- Concern about the high school students' abilities and willingness to participate and stay focused on the project;
- Anxiety about the complexity of the project and in particular the number of music stands to be constructed; and

- Dislike for what the students termed labeling of high school students based on class lessons focused on characteristics of at-risk youth.

Overall, the class was split on the usefulness of the first third of the class, in which the focus was preconstruction, constructability issues related to sustainability, and preparing to work with the high school students. Some students felt this portion of the class was incredibly useful whereas others felt there were limited takeaway messages applicable to other projects or classes.

#### **Reflections and Short Answer Questions: Construction**

In written reflection during the construction phase of the class, students expressed the following themes:

- Sustainable service-learning course provided different types of challenges than the traditional classroom activity, which was observed by all participants (these challenges mainly surrounded concepts related to leadership);
- A strong need for a prototype for construction, which was expressed by all students (the students felt that construction of the project would have been greatly enhanced had a prototype been constructed prior to the start of the project);
- Highly rewarding to see high school students come out of their shells, evolve, and learn new things (i.e., using new tools and learning sustainable concepts);
- Interactions between graduate and high schools students were highly successful, "a huge success" (students noted they were able to find a common ground with the high school students and felt like they could relate to them on a personal level);
- Students felt they had served as a very positive role model (they noted that any nervousness that they had regarding teaching others and speaking in front of a group quickly disappeared);
- Frustration that the project was not finished or delivered on time (students noted that the complexity of the project hampered their ability to teach about sustainability);
- Improvement in their teaching skills (students noted that they were now more skilled at explaining concepts related to sustainability in a variety of ways and students felt much more prepared for teaching and more comfortable teaching than prior to the course);
- Some students felt like they learned a lot from the experience, whereas others felt like they had not gained significantly;
- Whereas many of the students had previously participated in community service, many noted that this experience provided a new type of community service to which they had never previously been exposed;
- Identified significant impact of project constraints such as financing and schedule (students noted how issues related to sustainability increased project constraints particularly with respect to budget and schedule); and
- Students learned more from peers (fellow classmates) than in a typical class situation or performing a typical group assignment.

Overall, the majority of students reported that the project was a success. Some students remained frustrated that the project ended up behind schedule and that they were unable to deliver all 12 music stands at the end of the construction phase of the class (the remaining stands were completed by the graduate students on their own during the review phase of the class). However, all students felt that they had made a positive impact on the high school students and that this, in the end, was the most important outcome.

#### **Reflections and Short Answer Questions: Review**

In written reflection during the review phase of the class, students expressed the subsequent themes. This third set of reflections had



less common themes than the two previous sets of reflections. Therefore, the themes presented as follows may be less representative of the majority opinion:

- The basic level of sustainability taught to high school students did not contribute to significant learning for the graduate students with regard to sustainability (some students expressed the opinion that they could have learned more about sustainability in a more traditional classroom setting);
- The students identified that they were challenged in different ways than in traditional classroom settings [one specific area of challenge identified was the interface of architecture (i.e., design) to construction, and several students stated they felt better prepared to apply the knowledge they had learned in the sustainability service-learning class to real-world situations];
- The students reiterated the need for prototype construction to better facilitate project delivery;
- The students acknowledged the biggest learning opportunities related to leadership and management rather than traditional sustainability concepts;
- The students voiced a wide spectrum of opinions regarding how much they felt they had learned in the class, with some feeling they had learned an immense amount and some feeling that they had learned relatively little; and
- The students reiterated that the class was different from any previous community service experience.

Overall, opinions expressed about the class by the students in their third reflections varied significantly. Student generally felt the main takeaway messages had significantly less to do with concepts related to sustainability than leadership or management. This finding was mirrored in the short answer provided by students at the end of the semester in response to the question, "What was the most valuable thing you learned in this class." The six graduate students' responses included the following:

- "Problems faced if a project is poorly managed;"
- "The more you put into something the more you will get out of it;"
- "Critical thinking skills as related to construction problems/issues and how to interact with a group to find a solution;"
- "How to explain concepts to high school students in a manner that engages them in a discussion on the topic;"
- "Planning and time management are paramount to the success of a project;" and
- "Complexity of applying sustainability to even simple projects and the tradeoff between time and budget and being sustainable."

### Concept Maps

Concept maps were the final assessment technique implemented. Students individually completed a concept map in class at both

the beginning and end of the semester in response to the focus question, "How did the coursework interact with/touch upon environmental, economic, and social sustainability issues"? Anchoring the concept maps to the three pillars of sustainability (i.e., environment, economy, and social) is consistent with the application of concept maps in other research to evaluate learning related to sustainable development (Clevenger and Ozbek 2013; Lourdel et al. 2007).

Concepts maps were reviewed and analyzed by the participating faculty by performing the following tasks:

- Review maps for emergent themes (i.e., community, equity, and so on);
- Categorize themes in accordance with the service-learning constructs (Lichtenstein et al. 2011) (Table 1);
- Tally occurrences of concepts related to each theme identified (i.e., connect to community, serve the community, and so on) in precourse and postcourse concept maps; and
- Evaluate overall trends for the constructs relative to increase or decrease in number of occurrences in precourse and postcourse concept maps.

Table 2 presents the results of the concept map analysis.

The following findings are suggested by the thematic analysis of student concepts maps:

- After the class, students provided many more concrete examples the sustainable options and impacts of their project, and made less use of general sustainability terms (i.e., "use salvaged materials," "reduce fire danger" versus "build sustainably");
- After the class, students made more references to the importance of doing things locally;
- Prior to the class, students made significantly more references to individual roles in construction than collaborative roles; and
- After class, students talked more about leadership and self-esteem.

Whereas analysis of concepts maps remains somewhat subjective, it generally supports survey and reflection findings and suggests that the course's main impacts compromise increases in civic engagement and professional skills. One important difference, however, is that the concept maps suggest that students may have learned more about sustainability than they self-reported. Specifically, in surveys and reflections, students expressed the opinion that they had learned relatively little regarding concepts related to sustainability. However, as assessed by faculty versed in the subject, student postcourse concept maps indicated a higher level of specificity and understanding surrounding both the challenges and opportunities related to sustainable construction. This finding is consistent with previous research findings on sustainability service-learning, in which students demonstrated a higher degree of learning with regard to sustainability, and social sustainability in particular, than they self-reported (Clevenger and Ozbek 2013).

**Table 2.** Trends for Service-Learning Constructs Represented in Student Concept Maps

Construct	Theme	Precourse count	Postcourse count	Theme observed
Academic skills	Estimating	7	7	Improved ability to evaluate sustainable options and impacts
	Concrete example of sustainability	3	14	
	General sustainability terms	4	2	
Educational experience	Learning/education	8	6	Reduced focus on traditional academic skills
Civic engagement	Community	6	6	Greater focus on local community and collaboration
	Local	2	8	
	Individual rather than collaborative roles	22	2	
Professional skills	Leadership/self-esteem	1	4	Improved leadership skills
Personal growth	Equity/social justice	1	2	Greater awareness of social and equity issues

## Conclusions and Future Research

This research assessed the effectiveness of the case study sustainability service-learning course to increase student competencies related to sustainability. Three assessments techniques were used, as follows: (1) surveys, (2) reflections, and (3) concepts maps. In all cases, data collected was based on students' self-reported perceptions. Five constructs from community-based research were applied, as follows: (1) academic skills, (2) educational experience, (3) civic engagement, (4) professional skills, and (5) personal growth. Due to small sample sizes, statistical significance or generalizability are not achieved. However, trends are identified that promote the need for further course development and research. Results are slightly mixed, but suggest that the course successfully increased student sustainability competencies within the following key areas (Frisk and Larson 2011):

- Systems thinking and an understanding of interconnectedness. The research reported in this paper suggests students increased their competencies in system thinking. This finding is supported through multiple examples, including student short-answers identifying the value the class as creating "critical thinking skills as relate to construction problems/issues and how to interact with a group to find a solution," or illustrating "complexity of applying sustainable to even simple projects and the tradeoff between time and budget and being sustainable." Students generally demonstrated increased understanding of the complexity and messiness of sustainability after constructing the project. Postcourse concept maps also demonstrated a higher level of understanding of interconnectedness, with one student mapping connections between environmental and social pillars of sustainability using the concept of reduced fire danger resulting from the use of beetle-kill pine wood to construct the music stands. Arguably, hands-on construction projects in general serve as tangible illustrations of basic systems thinking and interconnectedness.
- Long-term, foresighted thinking. Admittedly, the research reported in this paper addresses this sustainability competency least well. Whereas little concrete evidence was produced to document an increase in such thinking by student participants, anecdotal examples suggest that increases in such thinking occurred. By its nature, construction projects focus on the here-and-now, requiring immediate attention and problem-solving skills. However, by working with and educating youth during the construction process, a dimension of longevity is created. Many students talked about the satisfaction of knowledge transfer and the rewards of educating others in their reflections. For many students, one of the most meaningful moments from the class occurred at the assembly in which the graduate and high school students presented the music stands to the elementary school student recipients. Acknowledging that the faculty involved also learned from the project, four generations of students, ranging from primary to Ph.D., were impacted by the small project in some way, creating a small scale exemplar of seven generations thinking. To date, several course graduates have already inquired how they can be involved now that they are professionals.
- Stakeholder engagement and group collaboration. Research results across all three assessment techniques demonstrate clear learning and improvement in group collaboration skills. Surveys results suggest that the case study sustainability service-learning course increased students' group and team skills (i.e., professional skills, Fig. 7) better than any class the students had previously experienced. Surveys related to civic engagement (Fig. 3) also showed an increase in the already high level of civic

engagement by the students. Finally, student reflections and concepts maps both suggest a high degree of learning related to group collaboration. Such results are not surprising, given that group collaboration was fundamental to the teach/build/learn class structure.

- Action-orientation and change-agent skills. More than any other competency area, the research reported in this paper suggests that the sustainability service-learning case study increased student change-agent skills. Specifically, students demonstrated and self-reported higher levels of, attention to, and interest in leadership and management skills across all three assessment techniques. One, apparently contradictory result was that students decreased their opinion that "it is important to perform community service" after taking the class (Fig. 3). This may in part be explained by the fact that students expressed on multiple occasions that this learning experience, although a form of civic engagement, was "unlike any community service they had previously performed." The writers hypothesize that student previous experiences might have felt like action for the community (community service), whereas this service-learning experience felt like action with the community (community action). Such a distinction has been identified as critical in previous research (Campus 2003). Overall, however, results suggest that students were more action-oriented after the class.

Research has shown that effective learning promoting sustainability competencies is currently lacking in higher education in general and construction education in particular. The research reported in this paper suggests that service-learning may be an effective educational pedagogy to support learning outcomes related to sustainability in construction education. This finding is based on data involving student perception of learning and does not necessarily represent actual learning. This is a larger challenge in the scholarship of teaching and is not addressed in the research reported in this paper. Nevertheless, the self-reported data strongly suggests that students learned a significant amount about teamwork and collaboration (critical skills for sustainability) by taking the course. Such a case study explores and highlights successful integration of sustainability into construction education, motivates additional course development, and models assessment techniques to compare and improve service-learning focused on sustainability. Recommendations for future research include further development and a more detailed assessment of similar courses to evaluate their impact on student sustainability competencies, evaluation of the role of the instructor on learning outcomes, and a comparison of actual learning outcomes versus students' perception.

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