AC 2012-4767: SYNERGISTIC LEARNING AND INQUIRY THROUGH CHARACTERIZING THE ENVIRONMENT FOR SUSTAINABILITY: AN INTERNSHIP-BASED BENCHMARKING PROCESS FOR SUSTAINABILITY INNOVATIONS

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Synergistic Learning and Inquiry through Characterizing the Environment for Sustainability: An Internship-Based Benchmarking Process for Sustainability Innovations

Introduction and Background

During the last decade, sustainability-related technologies and practices have become increasingly common among construction companies, both in the home office and on the job site, but the extent to which sustainability-related technologies and practices have been adopted by companies in the field has not been systematically documented. A need exists to better understand what types of sustainability-related innovations are most easily and effectively adopted over time by project teams in capital projects. This knowledge not only supports the selection of successful tactics for use in future projects, but also provides key information to rethink tactics that are not being widely diffused.

Establishing a benchmark of the current status of sustainability-related construction innovations is important not only for understanding which companies are using what practices and technologies, but also why they are choosing to use them and how to design future practices and technologies to be more successful. Benchmarking is a continuous process of measuring products, services, and practices against the toughest competitors or those recognized as industry leaders. Benchmarking in the U.S. construction industry is usually conducted by third party organizations such as the Construction Industry Institute (CII).

To reduce barriers and provide motivation to participate, ideally the process of benchmarking should be designed as a beneficial experience for people and organizations involved in the process, and should build upon activities already being undertaken by the stakeholders to maximize efficiency. Current approaches to wide-scale benchmarking of construction practice are time- and labor-intensive, and one of the biggest barriers to conducting benchmarking studies is lack of resources. According, few sources of data exist, especially in the commercial sector, to document what sustainability-related best practices are presently in use by the construction industry. New approaches are needed to benchmark industry practice that can efficiently and accurately obtain the required data with constrained resources.

Internships are one possible approach to establish the synergy essential for successful industry benchmarking over time. Student internship programs in the construction industry, either formal or informal, are beneficial relationships that foster student growth, enhance academic program relationships with industry partners, and challenge faculty to include current information in their curriculums. Internship programs are an integral part of many engineering and construction programs throughout the U.S., and partnerships between industry and universities are increasing in importance for a variety of reasons. The link between the classroom and the real world is essential to the growth of the student. Internships give students exposure to more than the academic side of an industry and enable them to apply classroom material more effectively. The benefits to students of exposure to engineering practice as part of a curriculum are well documented. Internships also engage industry and faculty and encourage the development of mentoring relationships. Overall, internships help to develop a well-prepared graduate who is ready to accept the roles required to become successful in his or her chosen career.
Research Goals and Objectives

The goal of this research was to explore the use of student internships as a means of benchmarking best practices in the construction industry while providing synergistic benefits for all stakeholders involved in the process. The objective was to design a model internship program involving faculty, students, and participating companies that could actively introduce students to systematic methods of inquiry and industry best practices while increasing their resourcefulness and value to companies during their industry experience. The model should also provide a platform for engaging faculty by providing a means of gathering difficult-to-obtain data from industry that could be used for research purposes, and it should return that data in aggregated form to industry participants so that they could benefit from the experience. Industry participants should also be able to benefit from the internship in other ways to offset the additional responsibilities required of their interns, including having the opportunity for best practice audits of their practices and receiving recommendations from the student interns/auditors as to how they can improve their practice.

The SLICES Internship Model

The Synergistic Learning & Inquiry through Characterizing the Environment for Sustainability (SLICES) Internship program is the innovative internship program model developed in this research to achieve the research goals and objectives. It provides a method for benchmarking current sustainability-related best practices being used in the construction industry, and returns useful industry benchmark data to faculty participants while providing value to participating firms and enhancing the internship experience of participating students. The program involves a for-credit course that requires students to undertake research and data collection during their internship programs in exchange for elective course credit. In addition to their normal internship job responsibilities, participating students collect data relating to current company practices that can be used to establish the current state of practice in industry and track the diffusion of innovations in practice. The resulting program benefits participating companies, students, and faculty by building on activities already undertaken by each.

Under the SLICES program, interns are provided with detailed protocols for collecting data about innovation and sustainability-related best practices, and are briefed on strategies for obtaining and triangulating data using multiple methods to answer the questions on the protocols. Five model protocols were developed for the SLICES program (Table 1), each focusing upon different aspects of corporate innovation and the adoption of sustainable construction practices. From a pedagogical standpoint, these protocols can be considered a formalized “scavenger hunt” for information about the company. From a research perspective, the protocols may be considered human subjects research, and should be evaluated as part of a formal application to each university’s Institutional Review Board (IRB). The full set of protocols used in the SLICES program for collecting benchmark data is available online as part of the Engineering Pathway Digital Library. Although the initial pilot test of the SLICES program required students to complete protocols on a specified timeline, later iterations provided students with the protocols in advance so that they could structure their data collection in the most effective way to coordinate it with their normal job responsibilities. The expectation is that students should need to spend no more than 5 hours per week at most completing the internship requirements for their course credit, in addition to the normal corporate responsibilities of their internship.
After enrolling as a SLICES intern, students undertake a twelve-hour required “boot camp” experience that introduces them to the protocols, research methods, and data collection practices that are important as they collect their data. Students also undertake multiple exercises and complete inventories to learn more about their individual learning styles, strengths, and weaknesses as a way to prepare for what they will face in the field. During this period, industry partners are also briefed about the internship program to make them aware of the student’s course-related responsibilities during the internship period. They are provided with documentation on the program along with contact information for supervising faculty. Participating firms receive a copy of the benchmarking results that are generated from each iteration of the program to provide a perspective on how their firm fits within the industry overall.

Table 1: Structure of Sequential SLICES Protocols

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Description</th>
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<tbody>
<tr>
<td>Protocol # 1 Internship Information</td>
<td>Focuses on understanding the student, their employer, and the job they were undertaking throughout the internship period. To complete this protocol, students contact their employers prior to the beginning of the internship to learn more about the company and their job profile.</td>
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<tr>
<td>Protocol # 2 Corporate and Leadership Innovativeness Factors</td>
<td>Designed to guide the student in collecting information about the company’s perspectives on innovation, this is the first protocol implemented on the job. Students collect information directly from the leader of their company, workgroup, or project through an interview and gather additional information from various other sources within their company. The questions focus on individual and corporate innovativeness and the metrics by which each company defines success.</td>
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<tr>
<td>Protocol # 3 Baseline Sustainability Best Practices</td>
<td>Designed to establish a baseline of the best sustainability practices the company employs, this protocol involves observing current practice for both general office procedures as well as on the job site, and asking questions of the people in charge of these practices to determine the extent of implementation across the company’s practice.</td>
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<tr>
<td>Protocol # 4 Understanding Adoption of Sustainability Best Practices</td>
<td>This protocol explores the experiences and reasons behind the best practices the company currently employs. Students are tasked to select three practices identified in the previous protocol that their company presently uses or has tried in the past but abandoned. The protocol guides students through a set of questions to develop a case study for each adoption experience.</td>
</tr>
<tr>
<td>Protocol # 5 Recommending New Best Practices</td>
<td>Based on the results of the third protocol, students choose three sustainability practices not currently used by their company and develop an implementation plan and recommendations for each practice. Recommendations are presented to company leadership, and their responses to the proposals are documented by the student.</td>
</tr>
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</table>
SLICES Impact on Student Learning

One of the major thrust areas of the SLICES research was to improve students’ social and emotional development in conjunction with cognitive development, thus enabling students to be more aware of their learning process and better transition to being lifelong learners. This was accomplished through three different evaluations used to determine the impact that the internship program had directly on students’ awareness of strengths, their managerial resourcefulness, and their perceptions of the program benefits. Each of these constructs was assessed using developed surveys that the students completed pre- and post-internship experience, with the exception of the program benefits survey, which was only completed after the completion of the internship.

The Strengths Awareness Matrix was developed to evaluate the change in how students perceived their personal strength characteristics. This assessment allows students to describe their strengths with phrases or adjectives and was then coded into 23 different categories for evaluation. The categories were based upon the most common responses received from the students. These categories were then separated into five groups that included work ethic, communication, personality, time management, trust and physical qualities. The data evaluation indicated the most notable areas of improvement measured were verbal communication skills and an awareness of their abilities to interact with individuals.

To help students think about how they personally approach tasks, they complete a Managerial Resourcefulness Survey early in the boot camp process that was adapted from the work of Kanungo and Menon. Resourcefulness is critical in performing leadership roles that require coping with non-routine, un-programmable, or ill-structured tasks. Managerial resourcefulness is a mediation cognitive and self-regulatory competency that is consistent with the meta-cognitive approach to self-regulation, and is a construct applicable to the types of tasks required of the students during their internships. The survey questions for managerial resourcefulness are either descriptive of individual behavior (e.g., “When someone interferes with my task, I get angry with him/her”) or were indicative of behavioral preferences (e.g., “I like people who would say ‘I can do it’ when faced with difficult tasks”). A six-point response format (“very characteristic of me” to “very uncharacteristic of me”) is used to rate these items. Students complete the survey prior to their internships and again after the completion of the program to determine whether their levels of resourcefulness have changed.

The results of the pre- and post-tests are compared to determine whether changes occurred during the internship period in student attitudes towards completing tasks. The major improvements identified from the survey center upon the ability to focus on tasks and details, and completing projects on time. These skills are essential to future academic and industry success, and support the goal of the program to have students improve their ability to perform independent research. From the post-survey sample of students participating in the internship in 2010, six of seven students rated the question “Information gathering is part of my initial problem-solving techniques,” as “very characteristic of me” as opposed to three of seven students who had the same rating on the pre-test, meaning that the number of students self-perceiving a strength in this area doubled after the internship. Additionally, improvement was achieved in how students approached problems. While five students answered “very much like me” on the pre-test to the question, “I tend to stop doing a job when major difficulties get in the way,” only one responded that way on the post-survey.
The results of the managerial resourcefulness survey reveal that the students had improved their attitude towards difficult tasks and independent research while improving their focus and attention to detail during the internship period. The survey also indicated that the students enhanced their abilities to persist in academic pursuits and how they approached intensive tasks. The data resulting from the students’ use of the protocols also speaks to their ability to complete intensive tasks.

Finally, the students’ perception of the program benefits is evaluated using a survey developed based on the major goals of the program. These are related to the successfultness of the boot camp, improvement in student communication skills including interviewing, improvement in self-confidence, and improved research skills. The survey includes eleven questions that students answered on a six-point Likert scale with 1 indicating the internship had no impact on the skill, and 6 indicating that the internship helped them to improve that skill greatly. The greatest impact areas indicated from this assessment in the 2010 class were the students’ ability to ask questions, their verbal communication skills, and their ability to present data verbally. Each of these questions received an average student rating over five on a six-point scale.

Overall, the results of these assessments indicate a positive impact on the growth and development of students’ social development as well their cognitive development as a result of participation in this program. These impacts on student learning and development illustrate the benefits to students as stakeholders of the SLICES program. Other benefits noted anecdotally by students include the opportunity to actively engage in learning more about their companies during their employment. The data collection protocols used by students are an opportunity to discuss leading edge sustainability best practices with their employers and explore how those practices work (or don’t work) in the field. Students report that the focused data collection experience helps them better understand the philosophy of their employers and supports making better choices about what type of company they would like to join following graduation.

**Other Outcomes of SLICES Implementation**

Now approaching its fourth iteration, the SLICES program offers multiple benefits for other stakeholders beyond participating students. Participating companies benefit from increased structured interaction with their student interns, and nearly fifty companies have participated in the program so far. By agreeing to participate in the program, these companies have the opportunity to learn about sustainability best practices of which they may not be currently aware through questions raised by students about the use of these practices. The investment of company time in supporting the student during data collection is returned when companies receive the summary of study results that helps them benchmark their current sustainability-related practices against their peers, and the student-developed recommendation briefs for sustainability practices that could be implemented. Some companies also welcome the chance to have their interns perform a guided sustainability audit of their practices, complete with recommendations of specific innovations that might be a good fit for the firm. Overall, while some firms might be expected to be reluctant to participate due to lack of innovativeness, to date no firms have been resistant on this basis.

Supervising faculty benefit by having the opportunity to engage students, particularly at the undergraduate level, in the process of research and obtain new sources of sustainability-related data that would otherwise be very difficult to collect. Faculty report anecdotally that company representatives seem more comfortable being candid with interns than with formal research teams from universities, resulting in data that may be more authentic to support research efforts. Partic-
ipating faculty have used the resulting data in a variety of ways, including publishing the results for industry benchmarking purposes, inclusion of case studies from Protocol #4 in graduate and undergraduate classes as examples of successful and unsuccessful innovation tactics, and as a point of departure for developing other faculty-led industry data collection efforts.

From a benchmarking standpoint, the resulting data provides a periodic snapshot of current practice that allows mapping of innovation diffusion across the industry. For example, Protocol #3 includes two major focus areas of best practice: corporate-level practices applicable as part of the firm’s general operations, and project-level practices applied in one or more specific capital projects with which the firm is involved. 37 corporate-level practices such as office waste recycling and green travel policies are included in the first part of the protocol. This list of practices was assembled from a variety of sources in the sustainable business practices literature. Interns are required to identify whether or not their companies currently use each of these practices through a combination of direct observation, review of documentation such as corporate sustainability reports, and interviews of corporate personnel. Figure 1 shows an example of the data resulting from this part of the protocol, with practices ordered by frequency of use.

The second part of the protocol lists 115 project-level practices that can be implemented on individual construction projects in eleven major clusters, as follows:

- Project Implementation Plans
- Sustainable Procurement Practices
- Sustainable Contracting Practices
- Temporary Construction Materials
- Sustainable Site Management Practices
- Sustainable Project Management Practices
- Sustainability Audits, Benchmarking, and Metrics
- Indoor Environmental Quality Management
- Solid Waste Management
- Energy Best Practices
- Alternative Transportation/Equipment

Interns are asked to determine the current status of each practice for their company across all the projects with which their company was previously or is currently involved. Practices range from use of bio-based form oils and dust suppressants, to on-site waste separation or coverage of sustainability in toolbox meetings, to use of occupant education plans and were derived from a variety of sources in the sustainable construction literature. Although the way in which some firms implement each practice may be unique or proprietary, students are only asked to determine whether the practice is undertaken in the benchmark study, not the details of how. Practices to focus for subsequent protocols requiring additional information are selected in concert with each student’s supervisors to avoid potential proprietary information disclosures. Based on interviews, direct observation, and participant observation, interns establish a value for each practice on a five-point scale indicating frequency of use. Explanations of each practice and links to web sites with more information are provided to clarify what each practice entails. Interns also have access to an internet-based discussion board to contact both their peers and supervising faculty with questions as the data collection progresses. Figure 2 shows an example of the type of data resulting from these types of questions.
Figure 1: Corporate-level Sustainability Best Practices
Areas for Future Research

Over the three iterations of its implementation, data collected by this study support a perception that the industry is embracing new technologies and adapting to a changing focus in the economy and construction industry. However, the data also suggest that there are a wide variety of practices and technologies that are not being used extensively. Additional research is needed to determine why some sustainability practices are more diffused than others throughout the industry. An extensive body of knowledge exists to explain diffusion of innovations as a function of innovations, the people or organizations that adopt them, and the context in which adoption occurs. While outside the scope of the present study, this direction of study is rich for further investigation. A better understanding of the factors affecting adoption is needed to formulate strategies to encourage adoption of sustainability best practices across a wider population of organizations and projects. As a first step toward that understanding, this study provides an initial benchmark of the state of the industry as a point of reference for future work.

The potential for the SLICES model to be expanded beyond the founding university is significant, and efforts are currently underway to disseminate the model to multiple institutions in the United States and beyond. Immediate efforts are focused on adapting the SLICES model to new contexts. In the U.S., some construction-related degree programs require internship participation, but many do not. There is a need for further research to evaluate how the SLICES model can be
applied in other institutional contexts and curricula, both where internships are mandatory and where they are voluntary.

Internationally, there has been interest in the program from universities in South Korea, New Zealand, Panama, Chile, and Colombia. While interested universities all have architecture, engineering, or construction students involved in practical internships, the nature and culture of these internships differs widely from context to context. Particular areas of research involve how to develop and deliver the introductory boot camp asynchronously in a distance-learning format and how to establish multi-cultural peer networks to support student learning, as well as translating the protocols and training materials into Spanish and other languages.

Additional steps include expanding and further developing the model protocols to broaden interest among faculty and industry. From an academic standpoint, there is interest in developing new protocols using qualitative data collection approaches that have validity for small numbers of interns. Expanding the types of innovations that can be benchmarked besides sustainability, such as safety best practices, information technology, or others, is also under consideration. The SLICES protocol design can accommodate a variety of types of practices that could be benchmarked, and thus has potential to be expanded to other disciplines beyond those involved with capital construction projects.

Acknowledgments

This study was funded in part under National Science Foundation Grant #0935102 - Synergistic Learning & Inquiry through Characterizing the Environment for Sustainability (SLICES): Improving Understanding of Real World Systems via Direct Observation/Reflection. The opinions expressed are those of the authors and do not imply endorsement by NSF. The authors gratefully acknowledge the contributions of the 54 undergraduate interns who collected industry data and provided important feedback about involving undergraduates in research to improve the SLICES program.

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