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The role of service-learning in heritage preservation and engineering education

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ABSTRACT: In general, universities in the U.S. have been slow to incorporate historic preservation training in engineering education although it is becoming increasingly common for engineers to be involved in historic preservation projects. In recent years, some faculty and students from the School of Engineering at the University of Vermont have become increasingly involved in research and field projects focused on heritage preservation. In particular, for the past three years, many civil and environmental engineering students at the University of Vermont have been acquiring working knowledge of the role of the engineer in historic preservation through hands-on service-learning projects involving historic structures. This paper presents a general philosophy of service-learning as a pedagogical technique, and how it has worked within the context of historic preservation engineering. Similar approaches to heritage preservation engineering education may prove to be beneficial in other parts of the world.

1 INTRODUCTION

Until recently, the role of engineering in historic preservation practice in the United States has not been particularly well-defined. Universities in the U.S. have been slow to incorporate historic preservation education in existing engineering curricula, although it is becoming increasingly common for engineers to be involved in historic preservation projects. At the School of Engineering at the University of Vermont, the involvement of engineering faculty and students in research and field projects focused on heritage preservation is increasing. The involvement has taken several forms, and each offers unique opportunities for learning:

1. Students from the School of Engineering and from the Graduate Program in Historic Preservation have been working with faculty and staff on laboratory research projects focused on heritage preservation topics.
2. Students from the School of Engineering and from the Graduate Program in Historic Preservation have been working with faculty and staff on field conservation projects on important historic sites.
3. For the past three years, civil and environmental engineering students at the University of Vermont have been acquiring working knowledge of the role of the engineer in historic preservation through hands-on service-learning projects focused on historic structures and sites.

The service-learning projects have been particularly effective in introducing civil and environmental engineering students to historic preservation. This paper presents a general philosophy of service-learning as a pedagogical technique, and a discussion on how the technique works within the context of historic preservation engineering.

2 SERVICE-LEARNING, HISTORIC PRESERVATION AND ENGINEERING EDUCATION

2.1 *Service-learning*

Service-learning is an approach to teaching and learning in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development (e.g. Jacoby, 1996, Furco, 1996). Service-learning can be largely experiential in nature, especially in engineering, which helps in developing a variety of investigative, organizational, creative, and communication skills in students. Service-learning promotes academic enhancement and personal growth through civic engagement in a credit-bearing course, with equal focus on both the service being provided and the learning that is occurring.

An important aspect that sets service-learning apart from simple community service is that the academic

enhancement (relevant to the course material) and personal growth are supposed to occur simultaneously with the community service, and is realized through student reflections. Reflection is considered a critical aspect of service-learning (Clayton and Moses, 2005) and is essential to the learning process and for improving retention of the academic material (e.g. Kolb, 1984). Reflection can be viewed simply as another word for learning, but what distinguishes it from some other forms of learning is that "reflection" grows out of experience (Clayton and Moses, 2005). Through critical reflection students analyze concepts, evaluate experiences, and form opinions; it provides them an opportunity to examine and question their beliefs, opinions, and values. It involves observation, asking questions, and putting facts, ideas, and experiences together to derive new meaning and new knowledge. Reflections can be of many forms including in-class discussions, keeping a journal, or writing a paper.

While service-learning has been well established in many disciplines and from early to higher education, engineering has been slow in adopting a true service-learning pedagogy (Tsang, 2000; Catalano, et al., 2000; Coyle, et al., 1997). However, recent efforts to incorporate service-learning into the engineering context have been noted in the literature (e.g. Oakes, et al., 2002; Padmanabhan and Katti, 2002; Mehta and Sukumaran, 2007; Zhang, et al., 2007).

As far as is known, the efforts presented in this paper are one of the first where service-learning has been conducted within credit-bearing engineering courses that benefited communities and non-profit organizations caring for historic structures. The central theme of the service-learning projects has been the application of quantitative engineering techniques and methodologies to the evaluation and remediation of heritage structures.

2.2 *Historic preservation needs in Vermont*

In Vermont, many excellent opportunities exist for conducting projects as community partnerships because most communities in the state (and NewEngland in general) are grappling with the reuse of publicly owned buildings and structures from the nineteenth- and early-twentieth century that have become landmarks in their communities. Often, the communities or organizations that care for these structures do not have access to engineering services. In many cases, the service-learning projects represent the first time that engineering expertise has been brought to bear on building pathology.

2.3 *Civil and environmental engineering education*

The faculty of civil and environmental engineering programs at the University of Vermont believes that service-learning projects, if conducted properly, can generate meaningful benefits for the local community while helping students develop academic and interpersonal skills. Service-learning projects are generally open-ended in nature and multi-faceted in that political, social, regulatory and economic issues are as important as the technical component. Thus, service-learning projects promote a systems approach to engineering.

Service-learning projects involving historic structures promote the systems approach to engineering very nicely. Students have to work with the constraint that historic fabric and structural systems be maintained to the extent possible while developing remedial strategies and designs. They develop multiple solutions, balancing project costs with other values, such as public safety and cultural heritage preservation. Project partners are community members with diverse professional affiliations so that students learn to work in contexts not dominated by engineers.

Although service-learning projects have been incorporated in many courses throughout the four-year curricula of civil and environmental engineering, historic preservation related service-learning projects have so far been incorporated in senior year courses: *Geotechnical Design* and *Capstone Senior Design*.

2.4 *Geotechnical design course*

In the Geotechnical Design course, students learn about subsurface investigations and analysis and design of shallow and deep foundations, retaining structures and slope stability. The course builds upon an introductory soil mechanics course where students learn about index, compaction, hydraulic, compression and shear strength characteristics of soils. The introductory course is a required course, whereas the follow-up course is a design elective. Typically, about 20 students take the geotechnical design course comprised mostly of seniors and two to three graduate students. The course is taught in the fall semester senior year.

Groups of four to five students are formed. Each student group is assigned a historic structure in Vermont for a semester-long service-learning project. The project spans a period of about 12 weeks and is worth 35 percent of the course grade. In past projects (2005–07), students have worked on shallow foundations, retaining structures and slope stability issues related to heritage facilities, a total of 12 projects. As part of the project work, students typically complete damage surveys, participate in archival research, and conduct site investigations using hand augers and sampling equipment (Figure 1a). *In-situ* testing can include borehole shear tests to estimate shear strength properties of soils as well as professional drilling activities when funds are available. Soil samples are collected

(a) soil sampling`using hand operated devices *(b) student performing a direct shear test*

Figure 1. Students collecting soil samples and testing them in laboratory.

to determine relevant soil properties. At a minimum, students perform index testing on soil samples. If soil samples of reasonable quality are obtained, students can perform consolidation and shear strength testing using fully automated consolidation, triaxial and direct shear devices (Figure 1b). Collected data are used in performing analysis, making recommendations for repairs, and preparing cost estimates. The projects conclude with comprehensive project reports and presentations.

2.5 *Capstone senior design course*

This course is offered in the last (spring) semester of the senior year. The Accreditation Board for Engineering and Technology (ABET) encourages different ways of integrating design content of individual courses (e.g. Padmanabhan and Katti, 2002, ABET 2007) to provide meaningful, comprehensive design experience. In general, capstone projects are intended to (Padmanabhan and Katti, 2002):

- Provide an open-ended design experience encompassing the major subject areas of civil and environmental engineering;
- Allow students to address various socioeconomic, environmental and political issues that can be associated with engineering projects;
- Provide an opportunity to function as a team, interact with community and seek their feedback;
- Develop interpersonal (written and oral communication) skills; and
- Develop life-long learning habits and skills to integrate seemingly unrelated ideas in the overall design.

Service-learning projects can be very effective in satisfying all of the above goals, especially the ABET criteria that are non-technical in nature. Originally, capstone projects were based on hypothetical circumstances and conditions. However, in the past two years (spring 2006 and 2007), all civil and environmental engineering capstone projects have been conducted as service-learning projects meant to address real circumstances in Vermont communities; two of these projects have been focused on historic structures.

2.6 *Organizational structure of service-learning projects*

Most projects require site visits on students' own time; project sites are ideally located within half an hour's drive of the campus. Project teams are typically composed of 3 to 5 students, and are formed based on student interests and schedule compatibility.

Important issues such as performance expectations, timelines and deliverables are provided to the students in the form of a technical memorandum. Students also sign a "code of conduct" document to formalize the process as well as make them realize their ethical responsibility towards their client (community partner).

As one of the project deliverables, students submit draft reports. Instructors provide direction for additional research and analysis. Final reports incorporating instructor comments are delivered in electronic and hardcopy formats. Instructors typically make minor final edits before passing documents on to the community partners.

Objectively grading an open-ended project is always a difficult task for instructors as opposed to grading a homework or examination question with a unique final answer. An open-ended project conducted in a group setting is even more difficult to grade. Based on the student feedback from the initial years, it was felt necessary to provide students a rubric on how they will be graded. In order to evaluate if every member of the group appropriately contributed to the project or not, peer evaluation forms were also developed. They are administered twice during the project, at the project midpoint and upon completion. The purpose of peer evaluation is to give students a chance to anonymously identify group members that may not be contributing to the project fully. If a student is consistently identified by peers as an under-performer, the instructor can take action intended to improve upon group skills and participation.

Student reflection sessions are scheduled throughout the semester-long projects. The reflection exercises include informal classroom discussions, peer and self evaluations, essay writing, and responses to surveys assessing project objectives.

Community partners are invited to attend and participate in project milestones. Community partners are typically present for initial site visits, mid-semester progress discussions, and final presentations, and are invited to comment on draft reports. Such communication is important to ensure successful projects from the perspectives of the students, instructors, and community partners alike. It is clearly communicated to the community partners that the analyses, designs and

Figure 2. Photographs of Grand Isle Lake House.

recommendations made by students should be checked by a registered professional engineer before adopting them in final designs.

3 GRAND ISLE LAKE HOUSE PROJECT

The Grand Isle Lake House is located on Lake Champlain in northwestern Vermont, and has been used as a project site for the Geotechnical Design course and as a senior capstone project. The building is currently owned by the Preservation Trust of Vermont, a statewide nonprofit committed to assisting Vermont communities in the preservation of their historic buildings, sites, and town and village centers. The Preservation Trust uses the Lake House as a special events facility in support of their nonprofit activity. Photographs of the structure are shown in Figure 2.

Originally constructed in 1903 as the Island Villa Hotel, the Lake House is a three-story wood framed and clad building in the vernacular Victorian style. Service-learning projects were organized to address differential settlement in the rubble stone and brick foundations, and deformations and local failures in the building frame.

The geotechnical design project was focused on movement of the perimeter stone walls and brick piers of the building foundation. Based on initial conditions survey, foundation movement had resulted in local failures of several floor frame connections and transverse movement of exterior walls and porches. Test

(a) initial site visit and inspection

(b) drilling activities

Figure 3. Site visit, inspection and subsurface investigation at the Grand Isle Lake House.

pits dug along perimeter walls and piers confirmed that foundations were very shallow.

A series of boreholes (Figure 3) were drilled across the site in order to determine water table level and the depth of bedrock, and to provide basic soil profiles. Based on bedrock and water table depths, students concluded that building settlement issues were not related to movement of a shallow clay mass over the sloping site. Students determined that the bearing capacity of the hard glacial till is adequate to support building loads, but suspected that the eccentric loading of the shallow foundations combined with the frost prone soil might result in heaving, subsidence, and rotation of the foundation walls.

Students participating in the senior capstone project the following semester used the soil data developed in the geotechnical design course to develop treatment recommendations for stabilization of the foundation, and expanded the project to address structural inadequacies in the building frame.

Working with ASCE Standard 32-01 (2001) (Design and Construction of Frost-Protected Shallow

Foundations), students developed designs for insulation of foundation walls and piers, as well as installation of horizontal insulation to reduce heat loss in the vicinity of these elements. This was coupled with a storm water investigation and development of a design for perimeter drainage to reduce the volume of water available for formation of frost lenses.

Working in conjunction with a professional engineering firm involved in the project, students examined one of a pair of trusses hidden in wall construction and supporting loads from the roof and upper floors over the primary public space in the building. Students measured and drew the truss, traced load paths through the building section, constructed a computer model of the truss, performed a plane frame analysis, and considered options for augmentation.

Based on the repair scenarios that they developed, students estimated costs associated with stabilization of the foundation, drainage improvements, and strengthening of the trusses. Results of their work, including treatment recommendations, were presented to community partners, university faculty, student peers, and local design professionals.

4 CONCLUSIONS AND DISCUSSION

Service-learning projects facilitate heritage preservation engineering education in several ways. For many students, the projects represent the first time that they are involved in documentary and fabric research for the purpose of establishing the conservation history of a place. Students consult archives, library special collections, and the resources held by the Vermont Division for Historic Preservation in order to evaluate the significance of a site and develop a conception of its original form. Examination of fabric evidence helps to establish construction and treatment chronologies. These are critical forensic skills that are not sufficiently developed in classroom learning.

Investigation of the sites requires student participation in field testing and soil sampling, destructive and nondestructive evaluation, measuring, and documentation using photography and scaled drawings. In the context of specific projects, a direct correlation is established between available resources and the treatments ultimately recommended. Students generate quantities based on field measurements for purposes of analysis and cost estimating. Using photography, field sketches, and computer-generated drawings, students document existing conditions and develop the basic data required for modeling and analysis.

Involvement with historic sites provides opportunities for learning about archaic materials and assemblies; these opportunities are difficult to duplicate in the classroom. As part of their field work, students are directly exposed to construction materials and ways of building from the past. Evaluating current conditions requires that they become familiar with archaic structural forms, and deterioration processes peculiar to older materials. Recommending treatments requires that they anticipate the interactions of these materials with any repair materials they intend to introduce.

Significance statements guide the selection of treatments. In developing treatments, students must factor the cultural significance of a site into their deliberations. This constitutes an important added dimension to a process that is often focused too narrowly on structural performance versus cost. Significance statements also help to broaden the context within which interventions are evaluated, so that in selecting treatments students must consider issues of cultural sustainability as well as public safety.

In developing treatment recommendations, students develop familiarity and facility with national and local standards for treatment of historic properties. For many students, this is their first exposure to the Secretary's Standards for the Treatment of Historic Properties, to local design ordinances intended to protect historic buildings, sites, and districts, and to funding instruments that support their rehabilitation. Learning to design within the parameters established by these standards helps to develop skills useful to anyone working with existing buildings and structures.

One of the most compelling aspects of the service-learning projects is the experience students have working on heritage sites. Project site selection is based, in part, on the power with which the sites convey their architectural and cultural importance. By working on these sites, it is hoped that students will acquire skills, memories, and a sense of the importance of the work that will last throughout their careers.

In the course assessments handed in at the end of the semester, students generally affirm that the service-learning projects are a good introduction to the diverse nature of engineering problems and solutions, the societal and economical aspects of engineering, and the inter-personnel skills involved in project work. A majority of the students complete the projects with the feeling that historic preservation is an important community activity, and that they have personally provided a meaningful service to the community. Most also express a preference for real-world service-learning projects to "made-up" projects.

In their rehabilitation work, community partners have already implemented some of the low-cost, low-impact solutions developed by students in their service-learning projects. At a minimum, student reports are useful for advancing project planning. Students usually perceive these projects to be time-consuming while in progress; however, they find the projects to be valuable learning experiences at the conclusion. Instructors will need to invest greater than normal time to plan, coordinate, provide timely

guidance, and grade papers and reports. However, these projects do bring a lot of variety and unpredictability to the classroom making the courses more interesting and rewarding for the students, instructors, and community partners alike.

Similar approaches to engineering education and historic preservation may be suitable for other branches of engineering and in other institutional settings.

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REFERENCES

ABET (2007), *Criteria for Accrediting Engineering Programs – Effective for Evaluations During the 2007–2008 Accreditation Cycle*, retrieved from http://www.abet.org December 7, 2007.

ASCE (2001) Standard 32-01 *Design and Construction of Frost-Protected Shallow Foundations*, ASCE, Reston, VA.

Catalano, G. D., Wray, P., and Cornelio, S. (2000), "Comparison practicum: a capstone design experience at the United States Military Academy", *Journal of Engineering Education*, 90, 471–477.

Clayton, P. H., and Moses, M. G. (2005), "*Integrating reflection and assessment to improve and capture student learning*", CUPS Workshop, September 26–27, University of Vermont.

Coyle, E. J., Jamieson, L. H., and Sommers, L. S. (1997), "EPICS: a model for integrating service-learning into engineering curriculum", *Michigan Journal of Community Service Learning,* 4, 81–89.

Furco, A. (1996). *Service Learning: A Balanced Approach to Experiential Learning. Expanding Boundaries:Serving and Learning*. Corporation for National Service.

Jacoby, B. (1996), *Service-learning in higher education*, Jossey-Bass Publishers, San Francisco, CA.

Kolb, D. A. (1984), *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, Englewood-Cliffs, NJ.

Mehta, Y., and Sukumaran, B. (2007), "Integrating service learning in engineering ethics", *Int. Journal for Service Learning in Engineering*, 2(1), 32–43.

Oakes, W., Duffy, J., Jacobius, T., Linos, P., Lord, S., Schultz, W. W., and Smith, A. (2002), *32nd ASEE/IEEE Frontiers in Education Conference*, Boston, November 6–9, F3A-1 – F3A-6.

Padmanabhan, G., and Katti, D. (2002), "Using community-based projects in civil engineering capstone courses", *Journal of Professional Issues in Engineering Education and Practice*, 128(1), 12–18.

Tsang, E., editor (2000), *Projects That Matter: Concepts and Models for Service-Learning in Engineering*, Washington, DC: AAHE.

Zhang, X., Gartner, N., Gunes, O., and Ting, J. M. (2007), "Integrating service-learning projects into civil engineering courses", *Int. Journal for Service Learning in Engineering*, 2(1), 44–63.