AC 2010-1890: INNOVATIVE COLLABORATION TO PROVIDE HANDS-ON EDUCATIONAL OPPORTUNITIES FOR ENGINEERING STUDENTS: INTEGRATING "HABITAT FOR HUMANITY" INTO A FIRST YEAR CONSTRUCTION MATERIALS COURSE

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Innovative Collaboration to Provide Hands-On Educational Opportunities for Engineering Students: Integrating Habitat for Humanity into a First Year "Construction Materials" Course

Introduction

In recent years, much has been written about the many potential benefits resulting from a freshman-level "Introduction to Engineering" or "Introduction to Materials" course. Despite these benefits, however, many institutions have been unable to add such a course to their engineering curricula for a variety of legitimate reasons. At the University of North Carolina at Charlotte, the creation of a new program in Construction Management as well as the conversion of the traditional Civil Engineering Technology Program from 2 to 4 years to accommodate freshmen allowed for the development of a new course series on construction methods and materials. Primarily intended for 1st year students, these introductory courses are relatively consistent at schools across the nation and typically address the history, physical properties, behavior, and application techniques of basic construction materials. The course texts are also generally similar in scope and address the same array of topics. Traditionally, each major topic, normally represented by a chapter in the text, is covered during a week or two of classroom instruction (2 – 4 lectures). While this methodology may be considered adequate for academically introducing students to the basics of construction methods and materials, it fails to adequately expose the students to how all the fundamental topics are interrelated nor does it normally provide meaningful hands-on experiences on real job sites. This paper reports on the results of a project that targets the course in "Construction Materials" to affect an evolutionary transformation marked by active-learning by augmenting instruction with real-world hands-on construction experience at local job sites. This paper discusses the integration of student involvement in a nonprofit, ecumenical housing program known as Habitat for Humanity.

The Courses: "Construction Methods" and "Construction Materials"

The "Construction Methods" course (ETCE 1121) is an introduction to the basic construction methods and operations typically employed on engineering projects. It is listed as a 3-credit hour course with two 75-minute lectures each week. Topics include basic construction and civil engineering technology, identification and selection of construction equipment and techniques, and an overview of the components and processes used in construction regarding concrete, steel, and wood-framed structures. Course Learning Objectives are noted in Table 1.

Consistent with the Course Learning Objectives noted in Table 2, "Construction Materials" (ETCE 1122) is sequentially a follow-on course to "Construction Methods" and studies the history, physical properties, behavior, and application of basic "Construction Materials." Selecting Basic Construction Materials, 7th Edition, by Theodore W. Marotta as the course text, topics include mineral aggregates, Portland cement concrete, masonry, wood, asphalt concrete, metals, plastics, and other materials. With an enrollment of approximately 100 students for Spring 2010, this course features two 75-minute lectures plus a 3-hour laboratory each week.

Table 1: ETCE 1121, "Construction Methods" Course Learning Objectives

ETCE 1121, "Construction Methods" Course Learning Objectives
Identify the professional and trades involved in civil engineering projects.
Identify basic building construction components, systems, and processes.
Identify construction equipment and materials.
Develop the ability to estimate basic material quantities.
Relate the significance of notable civil engineering projects.
Describe the role and impact of civil engineering and construction in society.
Identify and describe "Construction Methods" that are consistent with current sustainable construction practices.

Table 2: ETCE 1222, "Construction Materials" Course Learning Objectives

ETCE 1222, "Construction Materials" Course Learning Objectives
Define properties of materials in terms of thermal expansion, strength, stress, the modulus of elasticity, and elastic and plastic properties.
Identify the nature and properties of: • Asphalt. • Aggregates. • Portland Cement and Concrete. • Iron and Steel. • Masonry. • Wood and Lumber.
Perform calculations related to material properties such as absorption, gradation, strength (compressive, tensile, and flexural), modulus of elasticity, thermal expansion, and viscosity.
Identify and explain the role "Construction Materials" have in sustainable design and construction.

The laboratories provide opportunities to understand material properties through design, placement, and testing. Laboratory topics are conducted parallel with class topics to reinforce classroom instruction and enhance the progression of the class lecture materials from one topic to the next. In fact, this parallel structure of the classroom and laboratory program has proven essential to the course's success in giving the students the ability to link what is being taught to them during the weekly lectures to the laboratory work with the same materials during the same week. Specific laboratory topics that are covered include:

- Aggregate testing (two weeks conducting sieve analysis, specific gravity, and bulk density).

- Asphalt mix design (two weeks conducting the Marshall test and asphalt cement penetration).

- Concrete mix design and testing (six weeks to develop a mix design, prepare the mix, and conduct testing on fresh and hardened concrete). Note: One of the goals of the concrete laboratory component is to prepare students to pursue the American Concrete Institute (ACI) laboratory technician certification with some addition practice and studies.

- Metals testing (one week conducting tensile and impact testing).

- Wood testing (one week conducting flexural and compression testing).

- Masonry testing (two weeks conducting brick and concrete masonry unit testing).

Despite the relative rigor of this comprehensive lab program, these 1st year students still generally lack a good, first-hand experience actually employing materials, techniques, and procedures to produce a constructed facility. Consequently, this apparent need for practical experience coupled with the laboratory component of the course collectively underlined the course's compatibility with the Habitat for Humanity initiative described in this paper. Participation with Habitat for Humanity was viewed as a protracted "practical exercise" laboratory dealing with both methods and materials of construction.

Both of the courses discussed in this paper are common to both the Construction Management Program as well as the Civil Engineering Technology Program curriculum. As discussed previously, the construction management program at the University of North Carolina at Charlotte is a new program and is not currently accredited. The faculty and staff are evaluating available accreditation options and requirements including three possible venues for construction-related programs: (1) Construction Engineering Technology (CNET) through the Technology Accreditation Committee (TAC) of the Accreditation Board of Engineering and Technology (ABET), (2) American Council for Construction Education (ACCE), and (3) National Association of Industrial Technology (NAIT). A final decision is pending. However, the Civil Engineering Technology Program is ABET accredited and therefore both of the courses discussed in this paper are accredited through this curriculum.

Literature Review

Habitat for Humanity is a nonprofit, international housing program dedicated to eliminating poverty, housing, and homelessness through construction of shelters and homes. Student involvement on behalf of the University certainly provides an opportunity to lead through serving both those in need and the larger community as well. Since it was founded in 1976, Habitat has built more than 250,000 houses around the world, providing safe, decent, affordable shelter to more than 1 million people in more than 3,000 communities.[1]

Habitat demonstrates a commitment to diversity by enlisting people of all backgrounds, races and religions to build houses together in partnership with families in need. Through volunteer labor and donations of money and materials, Habitat builds and rehabilitates simple, decent houses with the help of the homeowner (partner) families. Habitat houses are sold to partner families at no profit and financed with affordable loans. The homeowners' monthly mortgage payments are reinvested and used to build still more Habitat houses.

Habitat for Humanity's work is accomplished at the community level by affiliates — independent, locally run, nonprofit organizations. Each affiliate coordinates all aspects of Habitat home building in its local area — fund raising, building site selection, partner family selection and support, house construction, and mortgage servicing. Habitat for Humanity operational headquarters, located in Americus, Georgia, USA, and its administrative headquarters, located in Atlanta, Georgia, provide information, training and a variety of other support services to Habitat affiliates worldwide.[2] This project worked directly with a local operational center in North Carolina located in Charlotte.

Integration of a Proven Methodology – Habitat for Humanity and Other Universities

The initiative reported in this paper has in fact been successfully integrated in a number of other venues. Several universities with construction management programs already partner with local Habitat for Humanity chapters as a base for student service-learning opportunities. These service-learning Habitat for Humanity projects typically run through a particular course where the activities performed by the students on the project coincide directly with material they are learning in the course.[3] Table 3 summarizes the current or past partnerships between a number of universities and local Habitat for Humanity chapters. Some universities establish the partnership with Habitat through their university Outreach Center while others maintain direct contact between the departmental programs and the Habitat chapters or through student organizations and clubs. This project built on the successful template of introducing students to construction materials through a course in the curriculum and then implementing a methodology generally consistent with a project based learning approach where the students work in teams to execute real-world constructive endeavors involving planning and building a home. It is widely held that project based learning contains two essential components: (1) a driving question or problem that serves to organize and drive activities, which taken as a whole amounts to a meaningful project; and (2) a culminating product(s) that meaningfully addresses the driving question.[4] This initial step into this arena is a deliberate attempt to capitalize on some of the distinctive benefits associated with project based learning including a deeper knowledge of subject matter, increased self-direction and motivation, improved research and problem-solving skills, and understanding how classroom learning connects to jobs and careers.[5]

Table 3: Universities and Their Partnership with Habitat for Humanity

University	Department & Course	Habitat Location	Partnership Basics
Louisiana State University.	Construction Management, CM1010	Habitat for Humanity of Greater Baton Rouge	LSU's Center for Community Engagement Learning and Leadership (CCELL) – service-learning partnership for LSU CM students
University of Cincinnati	Participation open to all UC students, faculty, and staff	Cincinnati Habitat for Humanity	UC121, Center for Community Engagement (CCE) – to forge key partnerships with the community
State University of New York	Construction Management		Environmental Science and Forestry (ESF/SU) chapter of Habitat for Humanity – service-learning
Georgia Southern University	Construction Management, Wood Structures Course	Statesboro Habitat for Humanity	
University of South Carolina	College of Engineering, U101-E, University 101 for engineers	Central South Carolina Habitat for Humanity	Project participation satisfies some of the 10 hours of community service required by the University 101 office
University of Texas Tyler	Construction Management	Smith County Habitat for Humanity	Service learning project for CM students to build a culture that creates leadership, professionalism and autonomy
University of Wisconsin Platteville	Building Technology Management, Industrial Studies 4530 Residential Planning and Design	Grant County Habitat for Humanity	Community serving as part of a class project, designing plans for Habitat for Humanity house
Clemson University	Architecture, landscape architecture and construction science	Pickens County Habitat for Humanity	Clemson University's Habitat for Humanity chapter, design contest with Clemson's Emerging Green Builders as a service-learning project for architecture, landscape architecture and construction science students
University of Nebraska Lincoln	College of Engineering & Technology, Architectural Engineering, Construction Graphing and Design		Student participation as part of a service-learning project, integrating theory with practice and community service with academic study

Program Results

Initially, program implementation focused on executing a "proof of concept" demonstrating the utility of integrating Habitat for Humanity into a freshman course in engineering materials. This project identified volunteer groups of students from the targeted course in "Construction Materials" to comprise a Habitat work force. The students met and deployed to the Habitat work-site on a Saturday morning that was coordinated with the local Habitat operational centers. (Deployments during the week proved impossible to navigate due to conflicting academic schedules.) Habitat projects tend to focus on single work packages such as wall framing as shown in Figure 1; other trade areas including siding, installing wall-board, and roofing are also equally popular. Prior to and immediately after the engagement, students were briefed and interviewed and completed surveys to document their impressions, insights, and acquired knowledge. Student involvement in the program will be ultimately assessed and implemented during this initial phase as extra credit into the student's final semester grade. Habitat personnel involved directly with the student program were also canvassed for assessment and feedback data.

Figure 1: UNCC Students Learning by Doing with Habitat for Humanity

The assessment results from this initial effort resulted from survey data, one-on-one interviews, and personal observations from the program administrator. Data was collected before, during, and after the Habitat mission. Some of the objectives originally envisioned as direct benefits from the project tended to be more far reaching and proved difficult to measure during this initial implementation due to the limited window of interaction with the students. (A more longitudinal study commensurate with full implementation is currently being planned.) Nevertheless, the following presents some emerging highly relevant insights into the impact of this program. Figure 2 indicates graphically the highly favorable student assessments for selected areas of interest. This subjective survey solicited student and faculty input on a scale of 1 – 5 where "1" correlated to little or no support and "5" indicated strong agreement.

- **Increased Student Engagement**: This outreach initiative was rated nearly 4.4 and reflected a perceived increase in the student engagement by providing many with their first hands-on experience with construction techniques and procedures; it provided an opportunity for them to witness how their chosen field can benefit not just an individual family in need but a whole community. In fact, during the deployment at the job site, local community groups arrived at the site to express their gratitude through refreshments and personal interaction. The students commented that this really impressed them of the critical and appreciated role they were playing not just in constructing the home but also in becoming a player in improving conditions within the collective community.

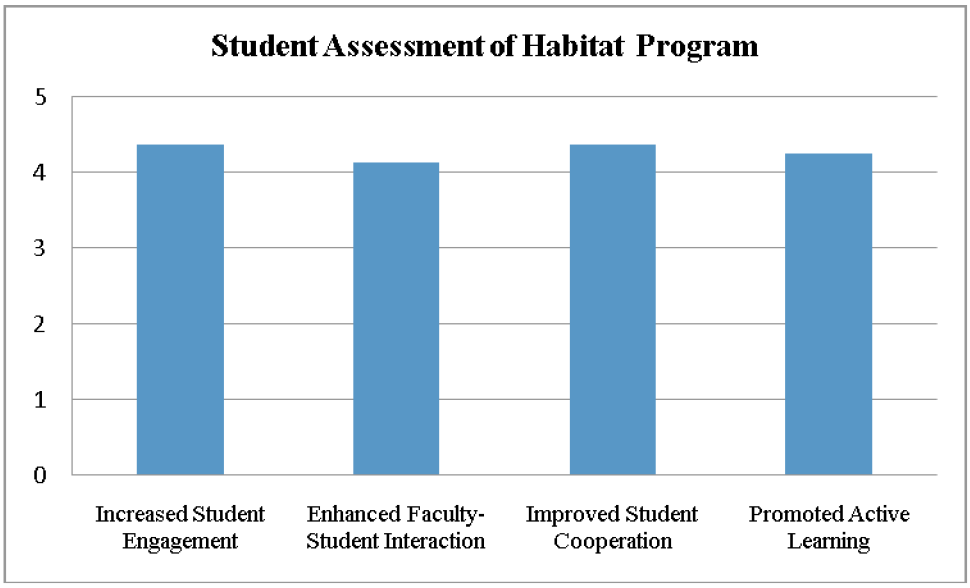

Figure 2: Participant Feedback for Areas of Interest Concerning Habitat for Humanity Integration into ETCE 1222, "Construction Materials."
(Note: Scores indicate the statistical mean for all student responses.)

- **Enhanced Faculty-Student Interaction**: By integrating faculty into the program working side-by-side, on-site with the students, faculty-student interaction was directly affected. Consistent with the rating of 4.125, students reported that a sense of commonality and collegiality developed as work crews served and achieved common goals. In fact, several students reported that at some point, they actually forgot that some of the faculty were actually faculty as opposed to simply a fellow member of their work crew. It was also noted during interviews that this relationship carried directly into the classroom and enhanced the learning experience both there and in the laboratory.

- **Improve Student Cooperation**: Rated at 4.4, the project participants reported a marked collegial atmosphere that promoted team work and esprit de corps among students as they served on construction teams dedicated to collectively constructing a specific feature of a home. Essentially, teamwork became absolutely critical for success and students developed a better appreciation for the truth of serving as part of a greater whole. Teaching points during post-interviews included discussions of synergy for the construction teams on the work-site and the potential for carrying these insights into other team projects required through their academic programs or as future practicing engineers.

- **Promote Active Learning**: Project participants also rated this area very high (4.25). Certainly, Habitat projects feature hands-on activities that directly promote active learning. Led by seasoned Habitat mentors as well as University faculty, students learned by doing as active participants in a real-world constructive endeavor. They transported materials, swung hammers, cut boards, constructed and erected frames, installed fixtures – students got dirty and had a blast. The passive learning they had grown accustomed to in many of their classes was displaced with active engagement and their high assessment testified to their preference.

The University of North Carolina at Charlotte also benefited from this project as an outreach initiative to the local community. Through the Office of Educational Outreach (OEO), the University already works in conjunction with numerous groups, departments, and professionals in an effort to reach out and connect to the community. These activities typically target "teachers, middle and secondary students, counselors, administrators, and other community stakeholders that are committed to strengthening the local infrastructure of education, i.e., curriculum, pedagogy, networking, resources, etc."[6] This Habitat program provided another link through community service and positively reflected the University's commitment to being a vital member of the Charlotte region. Particularly with the Habitat personnel but also with both the communities that were served and the fellow service organizations that worked alongside our students, the University of North Carolina at Charlotte developed a reputation for being a willing participant to lead through serving in this very tangible, constructive way.

Future Program Development

Based on successful implementation of this project, future program developments envision deployment of all students enrolled in this course to a Habitat worksite. The 3-hour labs affiliated with this course provide the infrastructure for planning, organizing, and implementing the program. The lab sections have a limited enrollment of 21 students each that provide a targeted, more manageable subset of the larger course enrollment. Typically, a total of four - six sections are normally created for this course providing essentially an equivalent number of separate "project teams" that would each in turn participate in a Habitat mission. Whether the three-hour labs will be long enough to support a Habitat deployment or if the program will be exclusively executed over the weekend has not been determined.

Conclusion

At the conclusion of a deployment to a Habitat jobsite, one student remarked, "I knew it was going to be hard work, but I didn't think it would be so much fun!" This feedback really delivers the bottom line to this experiment in active learning. The students engaged in a physically demanding constructive endeavor, but they benefited directly in a number of ways that were immediately apparent and perhaps some that may not be evident for some time into the future. This project executed a "proof of concept" demonstrating the utility of integrating Habitat for Humanity into a targeted freshman course in engineering materials. This initiative represents a vital tool in augmenting the educational experience of first-year students enrolled in a materials course that typically have very little or no professional experience in construction. Habitat for Humanity is a low cost venture but the program carries potentially highly significant benefits to student learning, for University public relations, for the Habitat for Humanity, and for the people and the community it serves.

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