



Renovating Education Inside and Outside of the Classroom: An Update on an Ongoing NSF Grant Featuring Innovative Initiatives to Revolutionize a First-Year Construction Materials Course

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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 through dynamic instruction and real-world hands-on construction experience at local job sites. Some of the initiatives described in this paper extend directly from previous research efforts stemming from funded research programs both here and at other university venues. A proof of concept for integration of Habitat for Humanity was executed under an internal curriculum enhancement program funded by the University of North Carolina at Charlotte in 2009-2010. The emerging results of that effort were published last year through ASEE and testify to not only the popularity but also the utility of this innovative effort.¹ This paper reports on the successful efforts to continue this practice coupled with additional techniques and methods supported by the National Science Foundation (NSF Award IEECI 1037779).

The Targeted Course: “Construction Materials”

Consistent with the Course Learning Objectives noted in Table 1, “Construction Materials” (ETCE 1122) is sequentially a follow-on course to “Construction Methods.” Listed as a 3-credit hour course with two 75-minute lectures each week, the Methods course introduces basic construction procedures and operations typically employed on engineering projects. The course serves well as a prelude to the Materials course including topics addressing 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 of concrete, steel, and wood-framed structures. In a deliberate parallel fashion, the “Construction Materials”

Table 1: ETCE 1222, “Construction Materials” Course Learning Objectives

ETCE 1222, “Construction Materials” Course Learning Objectives
<p>Define properties of materials in terms of thermal expansion, strength, stress, the modulus of elasticity, and elastic and plastic properties.</p> <p>Identify the nature and properties of:</p> <ul style="list-style-type: none"> • Asphalt. • Aggregates. • Portland Cement and Concrete. • Iron and Steel. • Masonry. • Wood and Lumber. <p>Perform calculations related to material properties such as absorption, gradation, strength (compressive, tensile, and flexural), modulus of elasticity, thermal expansion, and viscosity.</p> <p>Identify and explain the role “Construction Materials” have in sustainable design and construction.</p>

course employs Basic Construction Materials, 8th Edition, by Theodore W. Marotta as the course text, and studies the history, physical properties, behavior, and application of common construction materials such as mineral aggregates, Portland cement concrete, asphalt concrete, masonry, metals, wood, and other materials. With an enrollment of approximately 85 students for Spring 2011, this course features two 75-minute lectures plus a weekly 3-hour laboratory. The laboratories explore material properties through design, placement, and testing and are conducted parallel with class topics to reinforce classroom instruction and enhance the progression 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 additional 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) Association of Technology, Management, and Applied Engineering (ATMAE). 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.

Inside the classroom: Independent Blocks of Instruction with Guided-Inquiry Modules:

This project builds specifically on the results of another curriculum development initiative under an NSF, CCLI-EMD sponsored work, "Development of Project-Based Introductory to Materials Engineering Modules" (DUE #0341633). In this effort, a multi-university team of faculty developed five lecture modules for use in an Introductory to Materials course in a Chemistry program.² Modules were developed that teach how fundamental principles and effectively transformed the classroom environment; rather than students learning through lectures, they benefited from an environment characterized as more engaging, active-learning posture of working in teams to complete topical worksheets. The guided-inquiry worksheets provide data or information as background material, critical thinking questions intended to lead students in understanding associated fundamental concepts, and practical exercises involving applicable problems. The instructor's role evolved into one more consistent with that of a facilitator, guiding students through the material.^{3, 4}

In previous applications, guided-inquiry modules were designed to be utilized within the framework of traditional “lecture only” courses. The actual duration covered by a single module would vary but typically covered more than one lecture period. Modules were topic focused and took 1 – 2 weeks of class time. To date, the modules have been used in multiple introductory to materials engineering courses covering major topics such as polymers and ceramics.⁵ Modules were designed to be independent, complete, and detailed to support portability to other faculty and universities. A module typically would be distributed in booklet form to the students and would include a variety of items necessary for them to master appropriate learning objectives.⁶

In the course on construction materials addressed in this paper, the modules are currently a work in progress, being developed for each of the six primary topics comprising the major blocks of instruction for the course: aggregates, concrete, asphalt, metals, wood, and masonry. These blocks typically cover about two weeks of classroom instruction for each topic. The instructional methodology shared by the six blocks of instruction included:

- Preliminary Quizzes to measure initial knowledge levels and mastery
- Facilitation of Guided-Inquiry Modules for the Block of Instruction
- Post Quizzes at the conclusion of the Block of Instruction to measure student learning and mastery of associate learning objectives.

Future assessments will examine the progression of learning represented by student performance between the Preliminary and Post Quizzes. Student performance on mid-term and final exams will also be compared with historical data in order to measure the effectiveness of these initiatives. Subjective surveys will also be administered in the middle of the course and at its conclusion.

The Guided-Inquiry Modules stand independent from each other and address each separate block of instruction. Students submit completed Modules for grading prior to the Post Quizzes. Module are assessed and returned to students for use in preparing for future graded events. The modules share a common format and generally include:

- Background information on the topic
- Learning Objectives.
- Active In-Class Exercises.
- Demonstrations and Examples.
- Homework problems and solutions.

Outside the Classroom Transformation: Integrating Habitat for Humanity

As mentioned earlier, integration of Habitat for Humanity was executed under an internal curriculum enhancement program funded by the University of North Carolina at Charlotte in

2009-2010. The emerging results of that proof of concept were published last year through ASEE;¹ the literature review presented previously in that article is summarized here to present some general information for Habitat and to support this continued program initiative.

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. Founded in 1976, Habitat has built more than 250,000 houses around the world, providing affordable shelter to more than 1 million people in more than 3,000 communities.⁷ Through volunteer labor and donations of money and materials, Habitat builds and rehabilitates houses with the help of the homeowner (partner) families. Sold to partner families at no profit and financed with affordable loans, monthly mortgage payments are reinvested and used to build more Habitat houses. Habitat’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.⁷ This project worked directly with a local centers in North Carolina.

As Table 2 indicates, the initiative reported in this paper has 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. These projects are typically run through a particular course where the project activities performed by the students coincide directly with material they are learning in the course.⁸ Some universities establish the partnership with Habitat through their university Outreach Center while others

Table 2: 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	

Figure 1: UNCC Students Learning by Doing with 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 service-learning for architecture, landscape architecture 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

maintain direct contact between the Habitat chapters and departmental programs 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.⁹ 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.¹⁰

The highly successful program results from the initial integration of Habitat have been previously published and presented through ASEE.¹ Professors organized volunteer groups of students from the targeted course in “Construction Materials” to comprise a Habitat work force. 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. This team was one of two Habitat projects executed in February, 2011; seven more projects are currently planned for March-April. Figure 2 indicates graphically the data received from the proof of concept for Habitat project implementation. The assessment results from this initial effort resulted from survey data, one-on-one interviews, and personal observations from the program administrators. Survey data reports 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. Benefits included increased student engagement (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; enhanced faculty-student interaction (rating of 4.125) derived directly from a working environment that integrated faculty into the program working side-by-side with students to achieve a common constructive goal; improved student cooperation (rating of 4.4), the project participants reported a marked collegial atmosphere that promoted team work and esprit de corps among students as they served on several construction teams dedicated to collectively constructing a specific feature of a home;

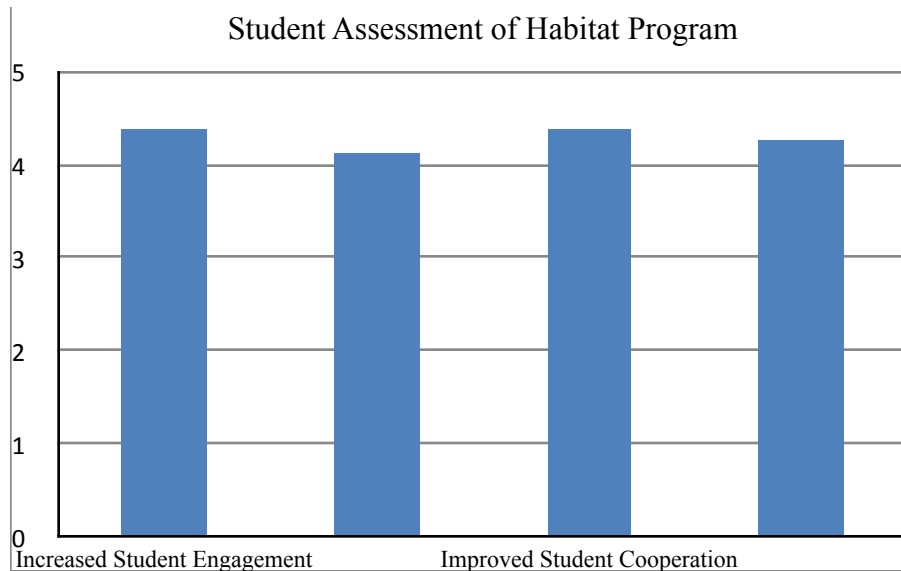


Figure 2: Participant Feedback for Areas of Interest Concerning Habitat for Humanity Integration into ETCE 1222, “Construction Materials.”
 (Note: Scores indicate the statistical mean for all student responses.)

and promoted active learning (rating of 4.25) with Habitat projects that featured hands-on activities with students learning by doing as active participants in a real-world constructive endeavor. It has also been noted that the University of North Carolina at Charlotte also benefited from this project as an outreach initiative to the local community. The Habitat program provides another link through community service and positively reflected the University’s commitment to being a vital member of the Charlotte region. This data represents three Habitat projects and approximately 30 students; the current program has seven trips planned and will involve the total course enrollment of about 85 students.

Conclusion

Innovation by its very nature should be an ongoing, iterative process continuously reviewing, assessing, and improving. The initiatives described herein are no exception and continue to evolve from their original conception and planning to implementation. This NSF Grant is only approximately 25% complete at this writing, but the emerging results of this effort already testify to a highly successful, popular program. At the conclusion of a recent 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 demonstrates the utility of transforming our standard of instruction both inside and outside the classroom to create an engaging atmosphere where students become eager to learn. This material is based upon work

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Bibliography:

1. Cottrell, David S., Chung-Suk Cho, Na Lu, and Robert Swan, "Innovative Collaboration to Provide Hands-On Educational Opportunities for Engineering Students: Integrating 'Habitat for Humanity' into a First Year Construction Materials Course," *Proceedings of the 2010 Annual Conference of the American Society for Engineering Education*, Louisville, Kentucky, June 2010.
2. Gleixner, Stacy, Elliot Douglas, and Olivia Graeve, "Prime Modules: Teaching Introduction to Materials Engineering in the Context of Modern Technologies," *Proceeding for the 2007 American Society of Engineering Education National Conference*, Honolulu, Hawaii, June 2007.
3. Farrell, J. J., R. S. Moog, and J. N. Spencer, "A Guided-inquiry General Chemistry Course," *Journal of Chemical Education*, 1999, Vol. 76, Pages 570-574.
4. Hanson, D. and T. Wolfskill, "Process Workshops – a New Model for Instruction," *Journal of Chemical Education*, 2000, Vol. 77, Pages 120-130.
5. Douglas, Elliot "Guided-inquiry Lessons for Introduction to Materials," *Proceeding for the 2008 American Society of Engineering Education National Conference*, Pittsburg, Pennsylvania, June 2008.
6. Gleixner, Stacy, Elliot Douglas, and Olivia Graeve, "Engineering Project Laboratory Modules For an Introduction to Materials Course," *Proceeding for the 2008 American Society of Engineering Education National Conference*, Pittsburg, Pennsylvania, June 2008.
7. "Habitat for Humanity," <http://www.habitat.org/cd/local/affiliate.aspx?zip=28223>, January 8, 2010
8. Bernstein, S. (2006), "Using a Service Learning Project to Enhance Collaborative Learning in a Construction Curriculum," ASC Proceedings of the 42nd Annual Conference, April 20-22, 2006, Fort Collins, Colorado.
9. "Houghton Mifflin's Project Based Learning Space," <http://college.hmco.com/education/pbl/background.html>, Feb 29, 2008.
10. "Priority Topic: Project Learning – Innovative Teaching in K-12 Schools, Edutopia, The George Lucas Education Foundation, <http://www.edutopia.org/projectbasedlearning>, Feb 29, 2008.