A Model for Sustainability: Bringing Deconstruction into Practical Learning.

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Realizing the current shortage of skilled craftspeople in the construction industry, construction management programs must find ways to entice students and prepare them for the current needs by providing them with hands-on opportunities that introduce them to new and updated methods. The intent of this article is to show how this can be done through a deconstruction project that works in cooperation with local educational institutions, business, and craftspeople. The pilot project described in this paper, which was performed during the spring and summer of 2008, involved four properties and drew in students, businesses and craftspeople from the community. The project was successful in providing the learning laboratory environment anticipated. Both supervisory and general volunteers were exposed to high quality content in a generally emergent context and a structure was created that could be replicated for learning possibilities in construction management programs. This report describes the project in detail and reports those areas of success, shortfalls, and lessons learned.

Key Words: deconstruction, construction education, learning experience, on-site learning, green construction, sustainable construction, hands-on, collaborative learning.

Introduction

As a nation, critical shortages of skilled craftspeople have created a situation where businesses are unable to meet the needs of their customers and clients because of a lack of qualified workers. As the current pool of craft workers continues to age, the knowledge, skills, and abilities of a valuable source of economic productivity is quickly concentrating in a diminishing percentage of the population. According to the Construction Labor Research Council (2005), industry growth and labor replacement needs over the next 5 years will lead to an increase in skilled labor shortages in the construction industry. Additionally, traditional recruitment paths for new entrants, including secondary and post-secondary training programs, have decreased consistently over the past 30 years.

During redevelopment, obsolete buildings must often be removed to make way for new construction. Deconstruction is an effective way to achieve this by selectively disassembling buildings rather than mechanically demolishing them. The deconstruction approach can yield new jobs, provide workforce skills training, small business development while conserving natural resources (Leigh, 2006). Deconstruction of unwanted buildings also holds significant promise as a recruitment and training tool for new entrants into the construction industry as it provides a valuable hands-on, real world learning environment for youth and adults who may wish to explore the construction trades as a career option. Additionally, deconstruction teaches and promotes green building best practices as the majority of "waste" materials are diverted from landfills through reuse and recycling. A newly developed building deconstruction training program by the non-profit National Center for Craftsmanship (NCC) offers evidence of a viable sustainability model as unwanted buildings are providing significant educational, environmental and financial benefits to participants.

Deconstruction is an emerging component of the green building industry. The United Stated Green Building Council (USGBC) recognizes deconstruction and construction waste management practices in its LEED certification protocols. As landfill costs and the costs to LEED certify buildings continue to increase, deconstruction offers a

cost-effective way to meet requirements that will only become more prescriptive. Using deconstruction as an educational tool can provide additional LEED certification points under "innovation in design." Deconstruction has also become a welcome player in the economics side of construction (Patel, 2008, Salent, 2003). Additionally, many construction programs include the majority of their students who have little if any practical construction methods experience. Deconstruction provides an opportunity to experience construction practices in the field in a controlled, learning laboratory environment. It uses a reverse engineering education model whereby students learn how things work by taking them apart. According to the literature (Faulk, B. & Guy, B. 2007), a maximum of 85 to 90 percent combined reuse and recycle rate of all materials generated from project activities might be achieved from a deconstruct project, thereby diverting large quantities of reusable materials from taking up space at a landfill site. That there is a strong future for a career field for deconstruction technicians is indicated by growing requirements from municipalities around the country that have mandated or are investigating ordinances regarding deconstruction practices in place of demolition where ever possible**.** Boulder, Colorado, has instituted a deconstruction mandate and Cleveland, Ohio, has a deconstruction initiative that designates sites where deconstruction will occur. New Jersey's Department of Environmental Protection is currently investigating deconstruction as part of its Global Warming Response Act Recommendation Report. Buffalo Mayor Byron Brown's announcement of his "5 in 5" Demolition to clean up blighted areas of the City references deconstruction as a viable alternative to demolition. California, Chicago, and The Army Corps of Engineers requires 50% reuse/recycle rate. Vermont's Waste Prevention Strategies recommends that the State "Institutionalize waste prevention, deconstruction, and recycling in project design; specify waste diversion in construction bid documents." The town of Atherton, California, located in the San Francisco Bay area has imposed ordinances for recycling and diversion, requiring that every demolition project be available for deconstruction, salvage and recovery prior to demolition. Those are just a few examples.

Methodology

NCC's Deconstruct Project was performed during the spring and summer of 2008 and involved four properties. Phase One involved three residential buildings and Phase Two added one additional house. The objective of the Deconstruct Project was to develop and deliver construction skills training though deconstruction, reuse, and recycling of a total of four existing residential buildings in Fort Collins, Colorado. The project provided an opportunity for training and developing community youth and adult learners in construction skills for emerging deconstruction technology and LEED certification protocols. It also provided a situation for creating awareness and educational opportunities for youth and adults in green-building and sustainable development and construction practices through a community demonstration program that included construction material recycling, reuse, and diversion of significant "waste" materials away from local landfills. The program was administered by the NCC non-profit dedicated to the preservation, enhancement and sustainability of quality craftsmanship that works with industry, institutional and government partners to provide education, training, community service and research to support the retention and extension of craft skills at the local, regional, and national levels. As part of this effort, deconstruction is extremely important. The purpose was to teach basic construction skills while providing an alternative way to take down buildings. Youth and adults learn emerging deconstruction technology and LEED certification protocols.

Goals were developed and used to guide both the anticipated and emergent program components of the project. These included:

- Develop a structured construction skills training program for volunteers, secondary and post secondary school students, local contractors and subcontractors and other community volunteers,
- Engage, recruit and train younger people to become the skilled craft workers of tomorrow,
- Provide an experiential learning opportunity for local youth interested in construction trade-related careers,
- Offer the opportunity for local craftspeople to pass on their knowledge and skills to the next generation,
- Create a "real world" building experience for high school, college, and adult students wishing to learn the building trades and make home building or other construction work their profession,
- Create a pilot and feasibility study for the economic and environmental viability of (green) deconstruction technology for sustainable development and construction.

The Deconstruct Project consisted of the several elements critical to successful project completion. First, key educational program goals were identified with regard to the type of student anticipated, including high school, college, community contractor and other adult learners. High School Students age fifteen to eighteen were identified as one of the primary student groups for the Deconstruct Project. Student volunteers from two local school districts were invited to participate through their association with their school's construction trades and career and technical education classes, or career to work programs. It was anticipated that thirty to sixty high school students would participate. College students of all ages and from Colorado State University, Front Range Community College and Aims Community College were invited to participate in the project. Students and teachers expressed interest in volunteering through their construction management, interior design, engineering, and education programs. It was anticipated that somewhere between thirty and sixty of these college students would participate. Community contractors, subcontractors, design professionals and other business people were also invited to participate. The content of the structured training opportunities was developed with a focus on elementary to advanced construction techniques and green building technology. The format included a combination of "classroom" and hands on activities. Sample class topics were to include architectural plan reading, deconstruction technology, cutting an existing roof to frame in a new roof for an addition, installing skylights and light tubes, installing or enlarging a window in an existing wall, blower door testing for residential construction, and air sealing and heat transfer in a home. Instruction was primarily by NCC members, volunteer experts and contractors.

Second, the project's research agenda was elaborated with key participant roles identified. Research components were primarily applied, i.e. what was learned and documented. Third, community service activities were developed with an emphasis on partnering with existing agencies, businesses and other non-profits. Community contractors, subcontractors, design professionals and other business people were invited to participate. Finally, logistical and operational needs were addressed and categorized with regards to the above listed elements.

Results

Educational Perspective

From an educational perspective, outcomes included learning of basic construction and deconstruction techniques, tool usage, and the fundamental experience of the physical requirements of construction work. Additionally, high school students from vocational education classes used the project experience to reinforce in-class learning at their schools. Special needs classes used the project to broaden their educational curriculum to include experiential learning to improve student self-confidence and esteem. At-risk program administrators used the project to provide community service activities as well as expose these students to career path opportunities as part of their own internal program requirements. Finally, the implementation of the phase two component of the project provided 6 youth participants with a 200 hour Deconstruction Technician certificate and an opportunity to participate in a 5-week, full-time work experience. The project achieved the majority of the outcomes anticipated with regard to the number and type of student anticipated. One hundred and ninety-five student learner volunteers participated, volunteering more than 3000 hours of time to the project. Of these, those aged 18 and younger represented more than 85 percent of the volunteers and more than two-thirds of the volunteer hours achieved. NCC has also developed a structured curriculum for Deconstruction Technician certification that was used in Phase Two of the project. The curriculum outline and associated materials has been reviewed by the local school district and a formal partnering agreement has been signed whereby district curriculum content will be taught for the next anticipated deconstruction training project for spring 2010.

Research Potential

The project's research agenda was fulfilled in that the outcome included a master's thesis proposal for a graduate student as well as the development of a construction safety class research project at Colorado State University. Additional research opportunities included a detailed analysis of construction material recycling paths as well as a curriculum development for deconstruction as a green building strategy. Also included in this area were a published journal article, two more currently under development and a submittal to the U.S. Green Building Council's standards committee for consideration as a LEED certification points qualification criteria.

Material Reuse and Recycle

Environmental factors focused primarily on the flow of material from the structures that were deconstructed. The condition of the recovered materials varied from satisfactory to excellent depending on project (several sites were involved). Re-certification is only necessary for materials intended for structural applications such as beams and floor joists. For these projects, lumber and steel was re-certified by licensed engineers who do field inspections and that met the requirements of the local municipal building officials. Total volume of materials generated on the project was 1430 cubic yards, of which 560 cubic yards entered the re-use stream via direct materials sales and donations to partner agencies such as Habitat for Humanity and ReSource. An additional 420 cubic yards were hauled to local recycling facilities, and 450 cubic yards hauled to the local landfill. Based upon the data, the deconstruct project achieved a 69 percent reuse and recycle rate, slightly less than the amounts the literature says might be reused and recycled. Phase One (three houses) achieved a 64 percent reuse and recycle rate while Phase Two (one house) achieved a 74 percent reuse and recycle rate. Financial factors for the deconstruct project included total direct costs of $52,853, with Phase One and Phase Two costs equaling $29,377 and $23,476 respectively. Of these total costs, total contributions from Imago Enterprises (property owner) represented 52 percent of revenue applied to project direct costs.

Community Involvement

From a participation perspective, the numbers varied and, in some cases, were less than expected. High school demographic participation was satisfactory through the first two week (three Saturdays). The age range of youth participants was expanded to include fourteen to eighteen-year-old students. Initial participation rates provided evidence to support the anticipated number outcomes. A combination of student cohorts participated in the project. As the project proceeded, it became clear that the youth component emerged as the primary driver since the majority of participants were under the age of nineteen years. Within the youth cohort (eighteen years and younger), a number of subgroups participated including general high school, vocational education class high school, special needs high school, and at-risk minors. Total participant numbers for this cohort was one hundred and seventy-two individuals (eighteen and younger).

College student cohort participation was relatively minor with regard to anticipated numbers and amount of outreach and engagement efforts dedicated to this group. Educational outcomes included university students accessing the project as a credit-based component of their degree programs as well as community service. Some college students visited the site as observers without actively participating in site activities. Overall participation by college students relative to the significant effort to recruit was satisfactory at best.

It was anticipated that twelve to twenty-four of local construction business community students would participate. While participation of this group was light, initial participation supported successful attainment of numbers for this group. The project did achieve the minimum anticipated number of business community learners and participants. The majority of the individuals participated as volunteers to promote their personal community service agendas through direct mentoring and instruction of the youth participants.

Adult learners included community volunteers with diverse backgrounds and educational aspirations. From general construction technology to specific deconstruction, materials re-use and recycling techniques, as well as mentors and role models for youth participants, the community adult cohort added significant educational value to the project. Numerous partners and participants emerged with regard to interest, resources, and good will. First, a partnership with a local non-profit and their at-risk youth cohort provided significant community service value and opportunity within the community. Second, community contractors, adults, and youth participated to assist with the educational and environmental goals of the project.

Lessons Learned

The biggest learning curve for the project directors, supervisors and students was experienced in the area of logistical and operational needs. The primary issues were human resource (volunteers and supervisors) availability, tool and equipment needs, funding requirements, materials management, and timeline and schedule constraints. Initial paid contractor time and resource commitment ran 10 to 20 percent higher than anticipated. This was because

of mobilization and ramp up requirements, which leveled off over the following weeks. Actual deconstruction of the first home began February 15, 2008 and went relatively smoothly and according to plan. The second house began on March 15, 2008 and the third house began on approximately April 7, 2008.

Maintaining general volunteer hours became problematic during Phase One of the project because of the purely volunteer nature of this portion of the project. During the first two weeks and three Saturdays, volunteerism was light and increased somewhat as the weeks progressed. Volunteerism remained strong and steady for each of the sixteen Saturdays of the sixteen-week project. Ultimately, the availability of volunteer labor adversely affected the anticipated progress of phase one of the project. The goal was to reduce each of the first three homes to their foundations. Both of the first two houses were reduced to the sub floor systems and the third house was partially deconstructed, being reduced to the bare frame superstructure. Phase two of the project benefited greatly from the lessons learned during phase one. The full-time team model used to execute phase two virtually eliminated the inconsistent nature of the volunteer effort experienced in phase one. The deconstruction of this fourth house was anticipated to take five weeks. The student team along with one project manager completed the physical deconstruction of this structure in just less than four weeks.

Materials management, storage and distribution for reuse required significant time and volunteer resources. The use of the on-site metal shop building was invaluable to the project for materials storage and distribution to the community through sales and donations.

Time line also became an issue. The Deconstruct Project was intended to offer hands-on opportunities for youth and adult students to learn elementary to advanced construction skills, deconstruction technology, and green building protocols. Structured classes were to be held on-site creating a "learning laboratory" environment during the deconstruction process. It became evident that, with the scope of the project and the numbers of volunteers available, it would take all of the efforts and additional volunteer hours to complete the project and satisfy all stakeholder minimum requirements. Two structured classes were scheduled for Saturdays during late March and early April. Marketing was inadequate and interest was minimal. It was determined that the deconstruction program was a full-time, full-focus activity and abandoned the seminar short course format anticipated during the planning stage of the project.

Discussion

The project was highly successful in providing the learning laboratory environment anticipated. Both supervisory and general volunteers were exposed to a lot of high quality content in a generally emergent context. Structuring the environment through "interpretive" media and "setting the stage" for specific curricular elements emerged as a desirable component. It is suggested that for similar projects, a more direct tie in to service learning curriculums at the post secondary level would be worth pursuing with individual instructors. This, however, can lead to a significant number of passive volunteers who are there to "check the box."

Anticipated outcomes included the increased awareness of opportunities in the construction trades as a rewarding career for youth and adults as well as the general improvement in community awareness, knowledge, and skill for construction, deconstruction and green building. Post-class surveys assisted in determining how high school students were influenced to pursue construction-related or similar careers. High school and college students did receive class credit for their participation and volunteering with NCC. The number and qualifications of Habitat for Humanity volunteers were anticipated to improve in the Fort Collins area as a result of their participation with the project. A number of community-based programs for sustainability would be enhanced and furthered.

Finally, and as a result of the exploratory nature of this project, it was expected that a number of additional positive, albeit unanticipated outcomes would emerge. As a direct result of the public relations component of the marketing plan, thousands of youth and adults were made aware of the benefits and opportunities in green building and deconstruction. The direct outcomes included a prime time public interest segment on regional Denver-based television 9 News at 6pm, a two-month long, repetitive public interest story presence on local Fort Collins Cable Channel 14, multiple radio segments on local KRFC Radio, and numerous articles in local papers including the Fort Collins Coloradoan, Northern Colorado Business Report, Berthoud Surveyor, and Loveland Times-Call.

Post activity written surveys were analyzed, a sample of which can be seen in Table 1; responses to general attitude and reaction to the experience (Appendix A includes an analysis of the post-activity survey results). In addition, brief interviews were performed with students and their teachers, which provided significant evidence that students were influenced in a positive way toward careers in construction or related fields. A number of high school students from Poudre and Thompson School Districts, Colorado State University, and Front Range Community College received class credit for their participation There were some interesting developments that were unanticipated including the discovery that a significant percentage of student volunteers were women. In addition, several community-based sustainability programs reported that their activities were enhanced and their missions furthered by their participation with the project.

Table 1.

General attitude and reaction to experience

Response to the following survey notions (check all that apply):	Checked (%)
1. Glad I did it and would do it again	50.8
2. Learned more than I thought I would	22.7
3. Became confident in my ability as the time passed	22.7
4. I was disappointed in the amount I was able to learn	2.3
5. It was something I would not recommend to others	1.5

All the emergent strands of this project continue to be assessed and modified as other information continues to be made available. In short, the program variables are still emerging. A number of thematic trends have emerged and promise rich areas of future investigation. First, as an educational strategy, the learning laboratory model of physically deconstructing houses or other buildings holds promise to be one of the most powerful educational tools of our time. With the continued public and private emphasis on green building and sustainable practices, the deconstruction model has shown itself to be strong in all three acknowledged (both industry and academy) categories of sustainable design and practice. The economic, environmental and educational benefits of NCC's Deconstruct Project suggest that, through efforts like this, a "best-practice" of sustainability can be determined and instituted at the national level.

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Appendix A

Knowledge and Skill Acquisition and Impact

Objective: The intent of the project was to positively impact the participant in terms of knowledge and skill, as well as attitude toward the crafts professions. Each participant was asked to complete a survey at the end of each experience in which they participated. The impact on development/acquisition of knowledge and skill was reported by the participant on this survey.

A.1 Reported Increase knowledge/skill regarding specific areas:

Safety:	
Site Security	*28.4%*
Proper use of safety equipment	*28.4%*
Safe use of non-power tools	*26.2%*
Tools:	
Number of new hand tools	*60.7%*
Number of new power tools	*17.8%*
Materials:	
Interior wall sheeting	*11.7%*
Wood characteristics	*10.8%*
Components:	
Fastener types	*55.6%*
Decorative hardware types	*44.4%*
Systems:	
Framing systems	*18.9%*
Siding & roofing systems	*16.6%*
Structures:	
Elements of Superstructures	*65.4%*
Elements of Substructures	*34.6%*
Facades:	
Elements of interior facades	*50.7%*
Elements of exterior facades	*49.3%*
Boundaries & Transitions:	
Interior/exterior (walls, roofing, insulation, window, and door)	*53.1%*
Interior/interior (walls, doors room layouts, flooring etc.)	*46.9*

A.2 Reported Increase knowledge/skill regarding general areas:

Principles of Setup or use of hand tools for specific application	*21.8%*
Usage of tools/materials for interior finish applications	*18.3%*
Environmental conditions (jobsite cleanliness, physical & space requirements)	*16.8%*
Engineering principles (load bearing, cantilever spans and support)	*13.2%*
Use of tools and materials for exterior finish	*11.7%*
Principles, set up and/or use of electric power wiring circuits and systems	*9.1%*
Principles, set up and/or use of power tools for specific applications	*9.1%*

General Attitude and Reactions to Experience

Response to the following survey notions:

Glad I did it and would do it again	50.8%
Learned more than I thought I would	22.7%
Became confident in my ability as the time passed	22.7%
I was disappointed in the amount I was able to learn	2.3%
It was something I would not recommend to others	1.5%

General Questions comments responses:

Emergent Themes in response to question: *"One thing I thought was particularly useful"*

- Using tools and materials properly
- How to deconstruct properly
- Hands on work, learning by doing
- Learning how everything works together in a house
- Having the visual & explanation of how things work
- Hard work is fun
- Learning by taking apart – systems, elements, construct processes, old codes
- Safety and safety equipment
- Structural bracing and reinforcement
- Blue print and layout
- Elements of older construction that are no longer used or appropriate

Emergent Themes in response to question: "*Second thing I thought was particularly useful and interesting*"

- Techniques for efficient removal of surface materials (i.e. roofing)
- Theory and principles of weight distribution, balance, and levers
- History evolution of construction techniques
- Environmental impact and awareness
- The way that we learned – hands on, one-on-one instruction etc..
- How to deconstruct properly
- Using tools and materials properly
- Safety and safety equipment
- Working in a team