

Green Construction: An Inventory of Training and Education Approaches in the United States

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The concept of green building is now accepted worldwide and green building approaches and materials are being adopted for all types of building projects. The United States is at the forefront of this movement and is leading efforts to minimize environmental contamination and natural resource depletion by the construction industry. However, as yet green building approaches generally focus on the decisions made during the planning and design phases rather than during the construction phase. The construction phase is crucially important for green building because traditional construction practices can lead to serious environmental degradation as a result of the tons of construction pollution and contamination from various sources that are created. Green construction education and training programs are being adopted by private companies, U.S. government agencies, and non-profit organizations. Some institutions also are developing in-house green construction education and training programs based on one or more requirements related to green construction. This study identifies major drivers of green construction education and training; identifies a spectrum of approaches to green construction training and education presently in use today; and provides a case study example of training being undertaken by a leading firm at the individual project scale and across the firm as a whole.

Key Words: Green, construction, education, training, project

Introduction

The concept of green building is becoming widely accepted as part of the effort to reduce environmental contamination and natural resource depletion due to human activity. In particular, the construction industry has begun to emphasize the use of green building materials and technologies because of the growing public awareness of the industry's significant negative impact on the environment in various parts of the world and the way buildings affect the health and well-being of the people using them, both directly and indirectly. The U.S. Energy Information Administration (USEIA)'s report, *International Energy Outlook 2011*, described the relationship between the construction industry and every other industry, explaining how it underpins every aspect of our society (USEIA 2011). The report also highlighted the relationship between energy and carbon dioxide emissions, a primary cause of global warming and pointed out that the continuing upward trend in energy consumption by the construction industry is having a serious negative impact on the natural environment, both in the U.S. and around the world. The U.S. Department of Energy (USDOE) has found that the U.S. building sector, which includes single- and multi-family residences as well as commercial buildings, is one of highest consumers of energy in the U.S., as noted in the Buildings Energy Data Book[1]. This website provides the following statistics:

- "The 97.8 quads of energy the U.S. consumed in 2010 represented 19% of global consumption-the second largest share of world energy consumption by any country; only China consumed more. The U.S. buildings sector alone accounted for 7% of global primary energy consumption in 2010."
- "In the United States, the buildings sector accounted for about 41% of primary energy consumption in 2010, 44% more than the transportation sector and 36% more than the industrial sector."
- "Total building primary energy consumption in 2009 was about 48% higher than consumption in 1980. Space heating, space cooling, and lighting were the dominant end uses in 2010, accounting for close to half of all energy consumed in the buildings sector."

In addition to energy considerations, the U.S. Green Building Council (USGBC) (2003) reports that buildings consume 12% of all freshwater, 30% of raw materials, and 70% of the nation's electricity, while at the same time

[1]http://buildingsdatabook.eren.doe.gov/ChapterIntro1.aspx (accessed on April 4, 2013)

generating 45-65% of the waste going to landfills and 31% of the mercury in solid waste, making an overall contribution of 30% to the nation's greenhouse gas emissions. Much of this is avoidable; for example, Miller (2009) argued that retrofits and smart design for buildings could have reduced carbon dioxide emissions by about 200 million tons per year. However, the USDOE predicts that the energy used in constructing and operating residential and commercial buildings will continue to increase gradually and will account for 45% of the nation's total energy consumption by 2034.

Although research into the green building aspects of the planning and design phase is very active, there has been a comparatively small focus on new opportunities to reduce the environmental impacts caused during the construction phase of a project. Current green building education and training programs often focus on how to achieve green building certifications, especially Leadership in Energy and Environmental Design (LEED), which are strongly influenced by the planning and design phase and are based on a building's environmental performance. Green construction technology continues to develop, along with new strategies that support the green building process. For instance, the USEPA (2006) has suggested that installing advanced pollution control devices and alternative fuel systems in conventional construction equipment can reduce air pollution considerably by using alternative fuel such as cleaner diesel, biodiesel, and electricity. Griffin (2009) predicted that the use of alternative fuels in construction equipment will increase as the alternative fuels become more common and the associated fuel supply chain becomes established. The U.S. government is also interested in developing greener construction technologies and strategies because this would focus attention on efforts to reduce environmental contamination or natural resource depletion during the construction phase.

To continue to diffuse green building best practices and innovations in the construction industry, it is vital to combine the development of new green construction technologies and strategies with green construction education and training programs that are continually updated to take into account the latest developments in this rapidly moving field (Tinker and Burt 2004). Pearce et al. (2010) pointed out that green building best practices in construction organizations are not uniformly distributed in their adoption across firms and projects, nor adopted to the extent to which they could be. One reason for these missed opportunities may be a lack of awareness of the benefits of green building innovation and how they can be effectively implemented on projects. In a survey of 87 mid-sized to large construction firms in the eastern U.S., Ahn and Pearce (2007) found that these construction organizations most commonly learn the knowledge or skills of green building construction by attending conferences related to sustainability issues and reading publications about green building techniques and materials. However, these means of acquiring knowledge are limited to individuals and may or may not result in effective diffusion of new ideas, technologies, and practices across the firm. How can construction firms more efficiently and effectively learn to implement green construction innovations to improve their environmental performance? What approaches to training and education are presently being used by leaders in the industry to achieve this aim, and how can those approaches be applied by others? To answer these questions, the objectives of this inventory of practice were to:

- Identify major drivers of green construction training and education in the U.S.
- Identify the spectrum of approaches to green construction training and education presently in use in the U.S. today
- Explore how a leading construction firm is employing these approaches as part of their green construction programs and projects in the U.S.

Ultimately, the study aimed to identify tactics that can be included in corporate green construction training and education and highlight tactics that are being implemented effectively in practice. Sources of data for the study included a review of the literature, interviews with stakeholders in industry (EHS Director, Senior EH&S manager, VDC manager) and examination of training and education materials presently in use by construction stakeholders.

Major Drivers of Green Construction Education and Training

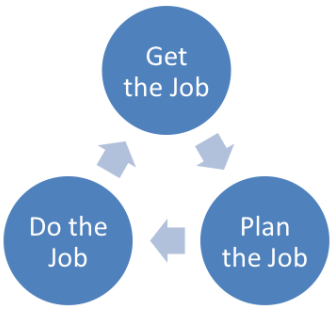

Figure 1: Functions driving the need for green construction education and training

In a competitive business environment, organizational activities that do not directly add quantifiable value to the bottom line are often considered "overhead" and may be given lower priority or investment than other activities. While motivated employees may seek out opportunities for learning using their own time and resources, formal investment in training and education by construction organizations establishes that improving knowledge and developing new capabilities are a priority, even though the direct benefits to the bottom line may be difficult to quantify. In the context of this paper, *training* refers to structured opportunities for learning that focus on developing "know how" skills of practice, while *education* denotes both structured and unstructured learning opportunities that enable learners to "know why" things work they way they do, based more on principles (Essenhigh 2000, Masadeh 2012). In general, training and education programs support a construction project-based organization's ability to do three distinct things essential to their business function (Figure 1).

First, training and education are an essential part of getting jobs in a qualifications-based procurement environment, where selection is based on a firm's qualifications to do the work instead of a low bid. Even in conventional procurement, training and education can also contribute to a firm's ability to prepare a competitive bid for a green project. In particular, training and education may be a pre-requisite for professional credentials pertaining to green construction, which serve as an indicator of capabilities in a firm's submittal package that can easily be compared across firms (Tucker et al. 2012). Professional credentials also often require continuing education as a part of credential maintenance, so there is a burgeoning industry in the U.S. devoted to providing approved training for this purpose. The Green Building Certification Institute (GBCI), for example, manages credentialing for the LEED rating system and is one of the primary reviewers and determinants of course content in the U.S. Table 1 lists selected green building credentials in the U.S. market (Pearce et al. 2012, Pearce & Suh 2013, Tucker et al. 2012).

Table 1. Selected Green Building-related Credentials and Associated Credentialing Organizations

Credential	Organization	Credential	Organization
Green Building Engineer Certification	Association of Energy Engineers	Certified Energy Rater	Residential Energy Services Network
Certified EcoBroker	Association of Energy and Environmental Real Estate Professionals	Building Energy Modeling Professional	American Society of Heating, Refrigeration, and Air Conditioning Engineers
Certified Energy Manager	Association of Energy Engineers	Building Biology Practitioner	Institute for Bau-Biologie & Ecology
Certified Indoor Air Quality Professional	Association of Energy Engineers	Building Biology Environmental Consultant	Institute for Bau-Biologie & Ecology
Certified Lighting Efficiency Professional	Association of Energy Engineers	Sustainable Engineering Certification	American Society of Civil Engineers
Building Performance Institute Certification	Building Performance Institute	LEED Green Associate	Green Building Certification Institute
Certified Sustainable Development Professional	Association of Energy Engineers	LEED Accredited Professional	Green Building Certification Institute
EEBA Master Builder	Energy & Environmental Building Alliance	Certified Commissioning Professional	Building Commissioning Association
Green Globes Professional	Green Building Initiative	Green Advantage Certified Practitioner	Green Advantage, Inc.

Green construction training and education are also essential to effectively plan the execution of green construction jobs. Green building aims to ensure that buildings reduce their consumption of natural resources and production of environmental contamination while improving the quality of life for not only building occupants but also building constructors, neighbors, and future generations. Competitively achieving the synergies necessary to meet these goals within constrained project delivery environments requires an evolving base of knowledge that can be achieved by training and education of construction stakeholders. Specifically, knowledge formerly the province of individual disciplines must now be shared to come to an optimal solution. The increase in use of integrated design processes coupled with pre-construction services mean that the constructor is a significant and valued source of knowledge to inform design (Tatum 2005). While the focus of constructors remains on the *process* needed to bring a building from

concept to completion, green projects also require attention to and knowledge of the desired *outcome* or *product* being built, ensuring that the process is managed to ultimately achieve the project's design intent.
Finally, training and education is essential in successfully executing jobs, particularly those seeking third party certification of environmental performance. Many individuals and organizations participate in the construction of a green project, so alignment of goals, objectives, tactics, and practices across firms plays an important role in achieving desired outcomes. On-site training, for example, can be used to introduce workers to requirements of a particular job and resolve any questions or concerns about how to meet those requirements. Given detailed requirements for compliance and documentation for projects seeking certification, proactive training and education helps workers meet requirements *before* problems occur that could threaten certification, such as substitution of non-compliant products during the construction process (Pearce & Fiori 2011). In contrast, reactive enforcement of project requirements through contractual means may not be possible until too late, after the window of opportunity for documentation has already passed, or after a prohibited product has already been used that might threaten indoor air quality requirements or toxicity limits. Given the necessity and value of training and education in achieving green construction goals, what are the ways in which it can be done?

Spectrum of Approaches to Green Construction Education and Training

Green construction knowledge in a construction firm can come from a variety of sources. It can be brought to the firm through new hires with outside training or experience, by hiring consultants, or by partnering with other organizations that have complementary expertise or experience. It can be cultivated among the firm's existing employees through training, self-study, or participation in outside events such as conferences, local green building councils, or standards development. It can also be brought into the firm through investment in physical resources such as a library or resource center, or access to online databases and tools. Finally, green construction knowledge may also be provided at no cost to the firm through the outreach and educational efforts of other stakeholders in the capital projects industry such as product manufacturers wishing to educate the firm about its green products, or clients sponsoring training for project team members involved in their products. Recent inventories (Pearce et al. 2012, Pearce & Suh 2013) of current training and education program types in use by construction firms include:

- **Job-site training**: Training can be provided for job-site personnel, either on a company-wide or project-specific basis. A general contracting firm may require generalized training for all field employees and may also offer training to subcontractors who are frequent partners on green projects.
- **Company-wide training**: Some firms have implemented company-wide training on both field practices and home office practices pertaining to corporate sustainability goals that involves all employees of the firm. This training may be delivered in-house or contracted in using a third party trainer.
- **Owner training**: Formal owner training on the correct operation of building systems is often a requirement of the commissioning or certification process for a project. Informal training may occur earlier in the project as part of the process of selling solutions to the client and informing them of the rationale behind decisions.
- **Craft worker training:** Some formal apprenticeship and training programs for construction craft workers now incorporate green construction content. For example, the National Center for Construction Education and Research (NCCER) has added two modules to its training lineup: "Your Role in the Green Environment" for all trades, and "Sustainable Construction Supervisor" for construction site superintendents. A final exam and third party credential are associated with both training modules.
- **Certificate and credentialing programs**: a number of institutions offer certification programs that can be completed as continuing education modules to receive recognition from the training body. Some of these programs lead to the opportunity to pass an examination for a professional credential to provide a service in the green building industry such as the Commissioning Process Management Professional (CPMP).
- **Degree programs**: College- or university-based degree programs that focus specifically on sustainable construction and related disciplines are emerging at both the undergraduate and graduate levels. These degrees are typically associated with a traditional program in engineering, architecture, or building science and may feature green construction as a focus area, minor, degree certificate, or track.
- **Green events**: Trade shows, conferences, and professional meetings also offer a way of staying current with the state of the art in green construction, and many such events are offered throughout the U.S. targeted to different stakeholder groups. The largest conference is GreenBuild, run by the U.S. Green Building Council. Attendees of this conference can receive continuing education credit toward maintenance of their LEED-related credentials.

In reviewing these different types of training and education programs, several dimensions emerge that can be used to characterize existing programs and identify opportunities for new types of programs. These dimensions include:

- **Format**: Programs can be either unstructured based on self-study or self-directed activities, or structured around a predetermined curriculum. Structured programs may be real time or asynchronous, and in-person or virtual. Hybrid programs may couple structured learning activities with self-study and review.
- **Delivery:** Programs may be developed and delivered by in-house resources, delivered in-house by outsourced resources, or obtained by sending employees off-site.
- **Role/Discipline:** Programs may be targeted to a single discipline or project role (e.g., designers; subcontractors) or may involve a mix of disciplines to better emulate a real project environment.
- **Specificity:** Programs may be developed to apply generally across all operations or projects, or may focus on the requirements and constraints of a specific project and its unique qualities.
- **Abstraction/Practicality:** Programs may be focused on general principles to explain the "why", on specific problems and processes to explain the "how", or a mix of the two.
- **Novelty:** Programs may focus on introducing new ideas and concepts to their audience, or may serve as a refresher or maintenance course to remind and prompt the audience of desired behaviors.
- **Assessment:** Programs can evaluate successful completion based on simple attendance, performance on an examination or test, or completion of a predetermined set of learning requirements such as an individual project, class project, or thesis.

Using variations of these dimensions, training and education programs can be designed specifically to suit the specific needs of the audience and the desired learning objectives in terms of content to be covered. How, then, are these types of programs implemented in practice? The following case study illustrates how one firm has employed a palette of training and education strategies to support green construction aims on its projects.

Case Study: Green Construction Training and Education at Skanska

Skanska has established a high reputation for green building projects including green construction processes and systems in the construction industry, largely due to their in-house green construction policy and their in-house green building practices guided by their Environmental Management System (EMS) and Safety, Health, and Environmental Management System (SHEMS). Skanska operates in-house green construction education and training programs that are both project-specific and company-wide. The following examples demonstrate the company's commitment to applying its EMS program to ensure that the project's environmental conditions meet the project owner's requirement that the project should be as green as possible. There are two different education and training programs related to green building: Project Introductory Training, which takes about 15-20 minutes and covers all the content workers must become familiar with when they join an environmentally friendly construction project such as those typically found on Skanska worksites, and EMS Implementation Training, which takes about two hours and aims to improve the skills related to EMS and increase workers' awareness of the necessity of green construction.

Project-specific Training: University of North Carolina Healthcare Hillsborough Project

The University of North Carolina (UNC) Healthcare project in Hillsborough is looking forward to becoming LEED certified, although project managers have not yet decided the specific level of certification for which they will apply. Skanska USA, the project's general contractor, examined the factors that they could control and manage and determined how best to apply their in-house green building program, based on the international ISO 14001 standards, for this project. The EMS is based on Skanska USA's Environmental Policy as the company's in-house green construction program. The purpose of the EMS is to minimize any harmful effects or negative impacts on the environment due to construction activities related to their building projects. In addition, the company's SHEMS was specifically developed to help them become one of the best green construction companies in the U.S. The requirements of both EMS and SHEMS equal or exceed all externally mandated standards, thus emphasizing to the company's employees and coworkers their commitment to environmental performance. The company requires all new employees on the project to participate in an education program to learn about the company's Environmental Health Safety program, including both EMS and SHEMS, before starting work.

The project introductory training is mandatory for all employees working on the Hillsborough project. Training is presented real time on site to a mixed audience of workers by an in-house senior project environmental health and safety manager, who briefly explains what EMS is and then moves on to focus on actual activities on the particular construction site that will be undertaken by the site workers. Content includes:

- The project team's activities for preventing construction site contamination: Soil erosion control, Fuel storage and delivery, Hazardous material control, Waste management plan
- Regulations and policy governing green construction: Carolina Star, Building Star, Skanska's Safety and Health Policy
- Introduction of injury free environment, harassment and discrimination, and substance abuse policy
- Introduction of several safety issues and cases related to OSHA
- Introduction of Emergency Action Plan: Stop, Clear, Notify, and Call

The content is a mix of project-specific and general information that may be either new to workers or a refresher if workers have had similar training on other projects. Assessment is based on required participation. Figure 2 shows the green construction training information materials displayed at the Hillsborough construction site to ensure their accessibility for onsite workers.

Figure 2. Green construction posters and materials

Company-Wide Training: Environmental Management Systems Implementation

In addition to project-specific training, Skanska also provides training for all its employees on implementation of Environmental Management Systems (EMS) in the company. The purpose of EMS implementation training is to help employees to understand the company's overall EMS system and process, and to improve their reporting skills and/or project management ability. This training is generalized beyond individual projects, and employees taking the two hour training are expected to be able to apply what they have learned on multiple projects. The training reminds attendees of the company's expectations, policy, and aspirations, and increases their level of awareness about green building projects being undertaken by the company. The training clarifies the following guidelines, as well as to emphasize the importance of continuing to monitor and measure all aspects of the project:

- How to measure achievement is up to the individual project team.
- Frequency of measurement is per permit, client, or Skanska requirement.
- Systems already established should be used to capture activities.
- Checklists, EHS program, and other features should be used consistent with what is written in EMPs.
- Ensure monitoring is sufficient, and that weaknesses are addressed as a result.

In addition, the training emphasizes the concept of *Continual Improvement*, because Skanska's EMS is updated or revised continuously to keep abreast of current legal requirements, roles and responsibilities, project scope, operational controls to reflect current construction activities, and aspects that should be opened or closed as needed. Figure 3 illustrates the concept of *Continual Improvement*'.

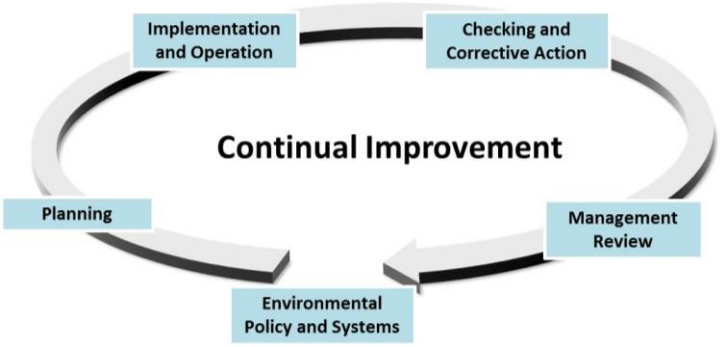

Figure 3. Concept of Continual Improvement of EMS

Discussion and Steps for Future Research

The industry's awareness of the importance of green construction is increasing steadily. Above all, construction companies are trying to find solutions that will enable them to engage in green construction practices for their green building projects, ranging from visible or tangible construction activities that can directly impact construction costs or other economic aspects positively to those regulated by codes, standards, and guidelines. In addition, both the owners' requirements and the companies' willingness to implement green construction technologies have a decisive effect on the rapid growth in green building projects worldwide. The UNC Healthcare project developed by Skanska USA is successfully running an in-house green construction training program based on the company's in-house Environmental Management System (EMS) to promote green building principles for all employees and coworkers. Skanska has a well-established green building philosophy and operates its in-house green construction training program for not only its own employees but also subcontractors working on its job sites. However, the education and training programs run by Skanska do not presently provide any green construction education and training opportunities to other building stakeholders such as owners and users.

Many opportunities exist to implement training and education programs for green construction that broaden the target audience and more effectively mimic the integrated project delivery environment in which many green projects are realized. In addition to company-driven programs such as those offered by Skanska, there are also other opportunities for training and education available to construction firms, including vendor-provided training, participation in local or national green building events, and focused hiring from degree programs with an emphasis in green construction. Further research is needed to evaluate the impacts of different types of training and education on the bottom line of construction firms, and to explore the development of new types of programs to take advantage of changes in training delivery methods and technologies. Many possibilities besides conventional training programs exist, and firms interested in positioning themselves in the domain of green construction should explore these options as they continue to evolve.

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