Fifth International Conference on Construction in the 21st Century (CITC-V)
"Collaboration and Integration in Engineering, Management and Technology"
May 20-22, 2009, Istanbul, Turkey

Why Sustainable Building Design and Construction? : Why Now?

Muge Mukaddes Darwish, Mary Frances Agnello
Texas Tech University, Lubbock, Texas, USA
mukaddes.darwish@ttu.edu, maryfrances.agnello@ttu.edu

Hendrika Buelinckx,
Texas Tech University, Lubbock, Texas, USA
Hendrika.buelinckx@ttu.edu

Abstract
Even though the movement toward sustainable design has made obvious strides in recent years, many of today's buildings, construction practices, and land-use patterns are still not sustainable. Modern architecture continues to produce uneconomic and uncomfortable homes which can be inhabited only with the aid of the most expensive devices for heating and refrigeration contributing to health problems, ecological degradation, economic disadvantage, and social injustice.

It is a well-known fact, that constructing and operating buildings, not only requires enormous amounts of energy, water, and materials; but also that it produces large amounts of waste. And depending on where and how they are built, buildings affect the ecosystems of the surrounding region. Furthermore, buildings create new indoor environments that present even more environmental problems and challenges to current and future generations.

Globalization has captivated and heightened our awareness on the importance of ecological integrity and diversity. Earth-friendly, sustainable building design and construction practices are no longer a mere fad, but have become an urgent necessity. Sustainable development requires a multi-dimensional way of thinking and collaboration among educators, practitioners, and industry partners. This paper will discuss the need for trans-disciplinary cooperation and will propose a strategy for interdisciplinary education in sustainable building practices aimed at future designers, constructors, and members of the society at large.

Keywords
Sustainability, Construction, Design, Ecological literacy, Education

1. Introduction

Sustainability is a global trend that has captured worldwide attention. In the U.S.A there is an increasing demand, in both public and private sectors, to understand sustainable design and construction practices. This demand is driven by realization of sustainable practices that not only help the environment but that can also improve economic profitability and improve relationships within many stakeholder groups.

Sustainability, as defined in the (also known is our common future), is that development "that meets the needs of the present without compromising the ability of future generations to meet their own needs." (p.8). This report was significant because it led to actions, including UN Earth Summits (in Rio de Janeiro in 1992 and in Johannesburg in 2002), International Climate Change Convention, "Agenda 21" programs,

and the creation of international sustainable development strategies. Figure 1 shows the interrelatedness of the mission of those concerned with ecological literacy—with applications to all of the construction-related and other disciplines.

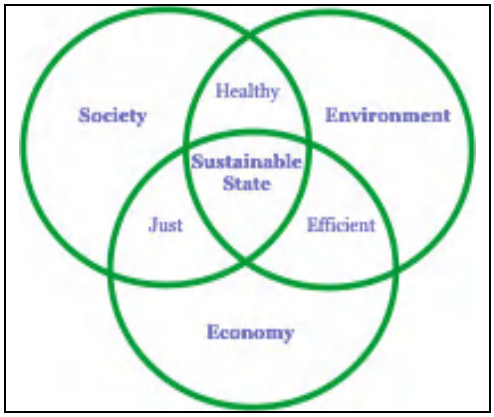

Figure 1: Sustainable Construction in the Contexts of a Sustainable State. Retrieved From http://www.state.nj.us/dep/dsr/sustainable-state/what-is.htm

David W. Orr (1992) widened the scope of sustainability in his seminal book "*Ecological Literacy*" from technological sustainability to ecological sustainability. Technological sustainability mainly deals with technological and ethical issues; ecological sustainability is considered an effort that affects all aspects of a culture. In order to adequately prepare us for the future, Orr envisions a dramatic shift in the existing pedagogies of all educational programs—a shift toward an earth-centered education. Earth-centered education entails a rethinking of both the theory and methods of education at all levels. Education informed by sustainability, ecological literacy, and green building principles also entails a renewal of the ways in which we teach construction engineering and architecture.

Broad Environment, Economic, and Education Needs: Importance of Problem

According to the United Nations, there are 6.7 million humans on earth and the number is expected to rise. From the time that measurement began, the level of carbon in 2006 took its largest jumped as three parts per million (Kibert, 2008). Human and environmental health are severely affected by pollution and weather extremes driven by climate change. In fact, buildings, infrastructure and the environment are inextricably associated. Energy, materials, water, and land are consumed in the construction and operation and maintaining of buildings and infrastructure. Energy, materials, water and land are all consumed in the construction operations. Buildings draws one-sixth of the worlds freshwater, use one-quarter of wood harvest, and two-fifths of its material and energy flows (Gottfried, D., 2005). Structures also impact areas beyond their immediate location, affecting watersheds, air quality, and transportation patterns of communities (Rodman and Lenssen, 1996). A global estimation by Davoudi and Layare (2001) asserts that 70 % of all timber is used for buildings, 45% of energy generated is to power and maintain buildings, and 5 % to construct them.

The construction industry is responsible for building the infrastructure that provides for wellbeing and a major portion of the economic activity in the U.S. By most estimates it generates about $879 billion in annual revenue and directly employs approximately 7 million people (Construction and the Environment: Research Foci for a Sustainable Future Workshop Final Report, 2005). By the year 2010, another 38 million buildings are expected to be constructed (Smart Communities Network, 2007). There are more than 76 million residential and nearly 5 million commercial buildings in the U.S. today. Combined, these buildings use one-third of all the energy consumed in the U.S. and two-thirds of all the electricity.

Without a doubt, the buildings and construction industry will continue to have significant impacts on the environment and resources.

The challenge is to construct them such that they use a minimum of nonrenewable energy, produce a minimum of pollution, and cost a minimum of energy dollars, while increasing comfort, health, and safety of the people who live and work in them. Improving the knowledge and understanding that construction engineers and architects possess of sustainable green construction techniques and systems could lead to significant improvements in the environmental performance of the construction industry (Cotgrave and Alkhaddar, 2004). The same is true for architects.

The challenge of 21st century requires that we make a transition to a new order of things that can be sustained; perhaps, the most important transitions must be in the building/construction sector. The concept of sustainability in building and construction must focus not only limited resources, especially energy, and on how to reduce impacts on the natural environment, but also on technical issues, building components, materials, construction technologies, and energy related design concepts. Furthermore in green/sustainable construction, economical and social sustainability such as cultural heritage aspects of the built environment must be also considered (Yitmen, 2005).

Defining Sustainable Construction

Sustainable construction may be defined as application of sustainable practices into construction industry including design and construction. Sustainable building is a rapidly growing practice in new construction development in the U.S.A, as the green development movement has been adopted by engineers, designers and builders. Life-cycle analysis shows evidence that sustainable design and building make a good economical sense and environmental impact.

The Texas State Energy Conservation Office (SECO) sustainable building design initiative and its sustainable school design initiative encourage and support schools, state agencies, architects and contractors to design and construct sustainable buildings that consume less fossil fuel, limit environmental impacts and improve worker health and productivity. A recent report from the Commission for Environmental Cooperation (CEC) concludes that promoting the green design, construction, renovation, and operation of buildings could cut North American greenhouse gas emissions more deeply, quickly, and cheaply than any other available measure. The CEC was established by Canada, the United States, and Mexico to build cooperation on environmental issues in North America. The CEC report notes that North America's buildings cause the annual release of more than 2,200 megatons of carbon dioxide into the atmosphere, or about 35% of the continent's total carbon emissions. The report concludes that the rapid deployment of currently available and emerging energy efficiency technologies could avoid 1,700 megatons of annual carbon dioxide emissions by 2030.

2. Methodology

The initial methodology entailed a thorough literature review, and face to face interview which focused on following topics:

- Defining sustainability and sustainable construction in order to identify what construction engineering and architecture students need to know about environmental issues.
- The impact of the building industry has on the environment, and the degree to which the negative impact can be improved in order to determine what level of ecological literacy is required for students.

- Identification of students' needs and education influences on learning in order to discern which barriers may prevent a more environmentally focused educational curriculum.
- Approaches that can implant courses into existing curricula which will include sustainable construction design and ecological literacy in the construction engineering and architectural teaching.

3. Results

GREEN design is a collaborative and interdisciplinary process. However, currently there is little or no collaboration between and among engineers, architects, and other related disciplines (Sosa, Eppinger, and Rowles, 2007). The United Nations (UN) declared 2005-2014 to be the Decade of Education for Sustainable Development, known as the UN EDSD (2007). This declaration sets a global challenge to integrate environmental issues into the entire curriculum of leading academic institutions. In order to meet this standard, an institute-wide inter and trans-disciplinary curriculum development effort for sustainable development and technology with the objectives to educate environmentally conscious and ecologically literate future designers and engineers is needed. Such an enterprise will train the lead decision makers in applying technology to sustainable building design and construction practices.

There is a trend toward sustainable projects which cuts across all construction segments (residential, commercial, heavy/highway, industrial and institutional) and that encompasses both the public and private sectors. Several cities have announced that all future government buildings will meet minimum sustainability requirements as established by the US Green Building Council's Leadership in Energy and Environmental Design (LEED) program. Among these are: Austin, TX; Boulder, CO; Cook County, IL; Los Angeles, CA; Portland, OR; San Diego, CA; San Jose, CA; San Mateo, CA; and Seattle, WA. The states of California, Maryland, Massachusetts, New Jersey, New York, Oregon, and Pennsylvania have also stated that all future government buildings will follow LEED Certification guidelines. At the federal government level, the Navy and the Army Corps of Engineers, as well as the Department of Energy and the Environmental Protection Agency, have also mandated that all future buildings will be sustainable (USGBC website, retrieved 1/2/2009).

The most relevant aspects of sustainability to relate to construction education were to develop understanding of the principles of sustainable construction process including, from planning and design to assembly, operation and disposal phases. Students in construction education need to be educated with high levels of ecological literacy in order to be able to influence emerging from traditional to green/sustainable construction practices in the construction industry.

Orr (1992) posited that educating students in environment issues and on environmental literacy will empower them to find solutions to environmental problems arising from past actions. Therefore ecological literacy is crucial in construction education. Environmental teaching should not be approached in a purely scientific perspective, but also ethics should be addressed as it identified in McKeown and Dendinger (2000). Scientific knowledge and political interventions alone are not able to solve the environmental problems; therefore attitude change is required, and this can be achieved through education. Orr maintains that ecological literacy can play a key role by creating environmental awareness and changing peoples' values, skills and behavior.

Barriers to implementing sustainable design and construction courses were identified as existing engineering and most architectural curricula's limited and prescribed credit hours with no place to add more courses. For example Construction Engineering Technology curricula at Texas Tech University (TTU) is fixed to 126 credit, and administrators resists adding any more courses. Also academic staff are often ideologically resistant to curriculum changes. Sustainable design and construction are relatively new

concepts in engineering and developing new courses demands extensive preparation which puts pressure on faculty.

Face-to-face interviews showed that TTU engineering and architecture students are passionate about the current trend in sustainable construction and are genuinely and deeply interested in mastering sustainability, green building, and LEED accreditation. TTU Student Senate (2008) passed a resolution demanding Engineering and Architecture colleges should teach sustainability and should educate students to be more ecologically literate. One other major barrier preventing sustainability in building education is lack of communication between the construction industry and academia.

In the area of sustainably the private sector has made much more progress than academia led by the U.S. Green Building Council, innovative building material suppliers, and passionate individuals and has now moved ahead of academia (Johnson, 2004; Business Leader, 2007; Hallford, 2007; Northcott, 2007; Northcott and Richter, 2007; Vanderhoff, 2007). Professional engineering and architectural organizations, such as the American Academy of Environmental Engineers (AAEE), American Society of Civil Engineers (ASCE), American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE), National Society of Professional Engineer (NSPE), Construction Management Association of America (CMAA), and the American Institute of Architects (AIA) have taken the lead in advocating sustainable principles and practices. A survey of The National Association of Home Builders (NAHB), Association of General Contractors (AGC), and Associated Builders and Contractors (ABC) websites revealed that all three organizations had an area of their websites that was dedicated to green construction or sustainable construction and provided educational materials to their members about the green construction (NAHB, AGC and ABC websites, retrieved 12/2/2008). USGCB reports that LEED Accredited Professionals (LEED APs) have demonstrated a thorough understanding of green building practices and principles and the LEED Rating System. More than 75,000 people have earned the credential since the Professional Accreditation program was launched in 2001(USGBC web sites, retrieved 1/ 3/2009).

Interdisciplinary Education in Sustainable Construction

The construction industry is complex and there are myriad professions such as architects, engineers, and construction managers etc., who are involved in the procedure of decision making. Therefore the ability of design and building of sustainable buildings require working closely with interdisciplinary team work. As it is argued in Jucker (2002), we need to overcome the disciplinary confinement of current education, that makes implementing sustainability in the build education difficult and that prevents each educator from looking beyond one's own narrow field of vision.

Dr. Darwish developed the Introduction to Green Development and Construction course, an undergraduate and graduate level offered on spring 2008, which was the first course in the College of Engineering to be offered to educate students in sustainable development and green construction principles and thought as an interdisciplinary approach to engineering, architect and construction management. Using an interdisciplinary approach to teach is a very positive manner in which to teach construction courses and introduce sustainability practices to students. Students benefit from working as teams like in real situations on a common project; such instruction prepares them better to meet the needs of the construction industry.

Topics covered in this course are:

1. Introduction to sustainable/green development
2. Green building resources and references
3. Advancing Green building technologies and innovations
4. impacts of building construction, operation and disposal
5. Green building assessment and process

6. Sustainable construction materials
7. Ecological design
8. Review for LEED-AP exam
   Introduction to LEED
   LEED design process
   Filling the LEED credit templates
   Site design
   Water management
   Energy use optimization
   Energy and atmosphere
   Construction materials sources

4. Conclusion

This paper identified that even with an increasing trend in sustainable construction practices, most buildings are still constructed in non-sustainable fashion. Constructing and operating buildings, not only requires enormous amounts of energy, water, and materials, but also produces large amounts of waste. And depending on where and how they are built, buildings affect the ecosystems of the surrounding region. Furthermore, buildings create new indoor environments that present even more environmental problems and challenges to current and future generations. Understanding of sustainability and the construction process are essential.

Beyond educating future ecologically literate designers, builders, and engineers, it is also requisite that members of the unsustainable development and building industry meet the difficult to create new avenues for development, design, construction, maintenance and waste disposal and also use of natural resources. Sustainable development requires the education of engineers, designers, managers, and technological professionals to engage them more actively in political, economic, technical and social discussions and processes to help set a new direction for the world and its development for better stewardship.

It is the responsibility of academia to ensure that future construction engineers, architects and managers are knowledgeable about current and significant future trends within the industry. A future trend in the construction industry is sustainable/green building. For academia to be prepared to teach, we need to be leaders in research on the impact of sustainable design, construction, and management processes. There is need of collaborative partnership between academia and construction industry with the vision of educating a new generation of designers and engineers within the principles of sustainable development. Therefore an institute-wide multi-disciplinary curriculum development effort for sustainable development is inevitable.

Institute wide multi-disciplinary curricula development and implementations will result in students being educated in real life situations and will eliminate the disciplinary confinement of current education that makes implementing sustainability in the building education difficult. Organizational support is necessary in order to succeed to develop and implement multi-disciplinary curricula to teach sustainability. In the U.S several schools, including Georgia Tech, University of Florida, and Michigan State were successful at creating multidisciplinary curricula to teach sustainability in engineering and related fields. The TTU interdisciplinary team continues their efforts to gain organizational support to find opportunities to develop multi-disciplinary curricula to create locally.

Planned Advocacy Initiatives includes

- Organize an annual awareness week on the TTU campus
- Organize a Conference(s) on Sustainability/Ecology / Green Building

- Lecture Series on Sustainability/Ecology/ Green Building
- Establish West Texas Chapters of national, international organizations involved with Ecological Literacy
- Organize an Invention/Convention for professional builders, product designers, etc.
- Venue for building and product trade shows.
- Support Community outreach programs and K-12 education initiatives

All efforts exerted in this mission are grounded in the assumption that the design, construction, and maintenance of buildings have tremendous impact on earth's environment and natural resources.

5. Related Definitions

Built Environment: "a comprehensive term used to encompass land and real estate development including design, construction, and/or management of existing and/or proposed projects" (Nobe, Harrelson, and Nobe, 2003).

Integrated design is a collaborative method for designing buildings which emphasizes the development of a holistic design.

Conventional building design usually involves a series of hand-offs from owner to architect to builder to occupant. This path does not invite all affected parties into the planning process, and therefore does not take into account their needs, areas of expertise or insights. In some cases, using the conventional method, incompatible elements of the design are not discovered until late in the process when it is expensive to make changes. In contrast, the integrated design process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall project objectives.

In addition to extensive collaboration, integrated design involves a "whole building design" approach. A building is viewed as an interdependent system, as opposed to an accumulation of its separate components (site, structure, systems and use). The goal of looking at all the systems together to is make sure they work in harmony rather than against each other.

Integrated design has evolved in conjunction with the rise of multidisciplinary design firms and sustainable design.(Wikipedia website, retrieved 12/21/2008).

Green Buildings ("Green") "…buildings that are designed, constructed, operated, and demolished in an environmentally and energy efficient manner." (Mead, 2001).

U.S. Green Building Council (USGBC): "The U.S. Green Building Council is the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work." (USGBC webpage, retrieved 12/21/2008).

Leadership in Energy and Environmental Design (LEED): "The LEED Green Building Rating System™ is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. Members of the U.S. Green Building Council representing all segments of the building industry developed LEED and continue to contribute to its evolution." (USGBC LEED website, retrieved 12/21/2008).

LEED Certification: **"**LEED Certification distinguishes building projects that have demonstrated a commitment to sustainability by meeting the highest performance standards." (USGBC LEED Certification website, retrieved 12/21/2008).

LEED Professional Accreditation: The LEED Professional Accreditation program is managed by the Green Building Certification Institute (GBCI). LEED Professional Accreditation distinguishes building professionals with the knowledge and skills to successfully steward the LEED certification process." (USGBC LEED Accrediation website, retrieved 12/21/2008).

6. References

AIA/COTE. (2006). *Ecological Literacy in Architecture Education 2006 Report and Proposal*. The AIA Committee on the Environment.

Architecture 2030. Retrieved on 11/1/2007 www.architecture2030.org

Borsch, S. J., and Pearce, A. R. (2003, February). "Sustainability in public facilities: Anaysis of guidance documents". *Journal of Performance of Construction Facilities, 17 (1), 9-18.*

Bowers, C.A. (2006). *Revitalizing the Commons: Cultural and Educational Sites of Resistance and Affirmation*. NY: Lexington Books.

Borsch, S.J., and Pearce, A.R. (2003, February). "Sustainability in public facilities: Analysis of guidance documents". *Journal of Performance of Construction Facilities, 17(1), 9-18.*

Brown, L. (1980). *Building a Sustainable Society*. New York: W.W. Norton.

Business Leader. (October/November, 2007). Going green: Saving the planet as a business model.

Cotgrave, A. and Alkhaddar, R. (2004). *Curricula greening in construction management programes.* Retrieved on 11/11/2008) www.rics.org

Cox, J., Fell, D., and Thurstain-Goodwin, M. (2002). *Red Man, Green Man* (London: RICS Foundation).

Davoudi and Layard "Sustainable Development" in *Planning for a Sustainable Future*, Batty Davoudi and Layard (eds), Spon Press, London, 2001.

Edwards, B., and Hyett, P. (2001). *Rough Guide to Sustainability* (London: RIBA Companies Ltd).

Environmental Education and Advocacy. (2005). Edward Johnson and Michael Mapp in(ed) Cambridge Press.

Green Home Building: Education and Opportunities. Retrieved 11/1/2007 www.greenhomebuilding.com/education.htm

Gottfried, D. (2005). Greed to Green. "In Nature There is No Waste" *World Build Publishing.*

Hallford, A. (November, 2007). Fort Worth adds some color to the greening of America: Going green in cowtown. *Fort Worth's Good Nature*.

Jucker, R. (2002). *Our Common Illiteracy. Education as if the Earth and People Mattered*. Frankfurt, M., Oxford, New York: Lang 2002 Environmental Education, Communication and Sustainability; Vol. 10.

McKeown, L. and Dendinger, D. (2002). Teaching Sustainability at Universities: Towards Curriculum Greening, University of Michigan.

McLennan, J.F. (November, 2004). Green Edge: The greening of Education.

Environmental Design+ Construction 8/17 K-12 and Higher Education Resources. Retrieved on 11/11/2007 www.usgbc.org

NAHB Website. (2008, December 02). URL http://www.nahb.org/page.aspx/generic/sectionID=480

Mead, S. P. (2001, April 4-7). "Green building: Current status and implications for construction education". *ASC Proceedings of the 37th Annual Conference* (pp. 169-178)., *University of Denver:* Colorado.

Northcott, K. (November, 2007). "Energy reality check: Green power for Texans and their co-ops". *Texas Co-Op Power*, 6-13.

Northcott, K., and Richter, R. (October, 2007). "Energy reality check". *Texas Co-Op Power*, 6-14.

Orr, D. W. (1992). *Ecological literacy*. Education and the transition to a postmodern world. Albany: State University of New York Press.
Perdan, S., Azakapic, and Clift, R. (2000). "Teaching sustainable development to engineering students". *International Journal of Sustainability in Higher Education*, 1(*3*) 267-279.
Plessis, C. D. (2001), Agenda 21 for Sustainable Construction in Developing Countries, *First Discussion Document*, CIB, CSIR.
Rosenberg, H., MESM, Merson, A., and Funkhouser, J. (2003). "LEED™ and the general contractor, or how we stopped worrying and learned to embrace green". *Proceedings of the Greenbuild International Conference & Expo*. Pittsburgh, PA.
Kibert, Charles, (2008). *Sustainable Construction: Green Building Design and Delivery*, J. John Wiley & Sons, Inc.
Sosa, M.E., Eppinger, S.D., and Rowles, C.M. (November 2007). Are your engineers talking to one another when they should? *Harvard Business Review*, 133-142.
Tinker, A. K. and Burt, R. (2003, April 10-12). "Greening" the construction curriculum. *ASC Proceedings of the 39th Annual Conference, Clemson University – Clemson, South Carolina*, 113-118.
Turning Down the Global Thermostat. (Retrieved, 11/11/2007). http://www.metropolismag.com/html/content_1003/glo/index.html
UN Decade for Education for Sustainable Development (2005-2014). Retrieved on 11/1/2007. http://portal.unesco.org/education/en/ev.php-URL_ID=23279
UNESCO. From Rio to Johannesburg: *Lessons from a decade of commitment*, UNESCO 2002. http://www.unesdoc.unesco.org/
USGBC. (September, 2006). New Construction & Major Renovation, Version 2.2, Reference Guide, Second Edition.
USGBC LEED Website. (2008, December 21). URL http://usgbc.org/LEED/LEED_main.asp.%20(2008)
Vanderhoff, M. (December, 2007). Grease monkeys go green: A new breed of car mechanics tune up the repair business. *Utne*, 80-81.
Williams, K.C. and Burst, R.A. (2007). Continuing the ranking game: Using ASC publications as one criteria for the ranking of the C-school. College Station, TX: Texas A& M.
World Commission on Environment and Development. (1987). *Our Common Future*. New York: Oxford University Press.
Wolfe, V.L. (2001). "A survey of the environmental education of students in non-environmental majors at four-year institutions in the USA". *International Journal of Sustainability in Higher Education*, 2(*4*), 301-315.
Yitmen, I. (2005). "Globalization and competitive strategies for sustainable construction in a developing country: North Cyprus construction industry". *10DBMC International Conference on Durability of Building Materials and Components, LYON (France), 17-20 April 2005*.