

# Incorporating Sustainable Development And Environmental Ethics Into Construction Engineering Education

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## ABSTRACT

The importance of engineers in today's society is great and obvious. Construction engineers make decisions that often have a critical impact on the environment and society. This enhanced ability to impact others makes sensitivity to ethical and social concerns a must in the construction engineering professionals. These observations underscore the importance of ethics for education of engineering students. A first step in the right direction assumes improving the knowledge and understanding that construction engineers and related disciplines of sustainability and GREEN construction techniques and systems could lead to significant improvements in the environmental performance of the construction industry. Education for sustainability in general is a process that develops students' awareness, competence, attitudes and values, enabling them to be effectively involved in sustainable development at local, national and international levels, and helping them work towards a more equitable and sustainable future. The objective of this paper is to explore the rationale for teaching sustainability and engineering ethics within a decision-making paradigm along with a critical appraisal of ways to achieve related outcomes. Additionally, it aims to assist those who are increasing their understanding of engineering education for sustainable development

**Keywords:** Education, Sustainable Development, Green Construction, Environmental Ethics

## INTRODUCTION

Bowers (2006) argued that educating students in environment issues and raising their ecological literacy will empower them to find solutions to problems arising from past actions. Therefore, ecological literacy is crucial in engineering education. When we introduce environmental teaching into engineering, it should not be approached from a purely scientific perspective, but also ethics should be addressed as they are identified in McKeown-and Dendinger (2000). Furthermore, ethics should not be treated as peripheral to technical considerations but integral to them. Scientific knowledge and policy changes alone are not able to solve the environmental problems; therefore attitude change is required, and this can be achieved through education. Orr (1992) maintains that ecological literacy can play a key role by creating environmental awareness and changing peoples' values, skills and behavior.

The term *education for sustainability* or *sustainable education* (UNCED, 1992) complements a number of fields such as environmental education, multicultural education, conservation education, global change education, ecological literacy education, as well as sustainable engineering in broad terms. Education for sustainability, in general, is a process that develops student awareness, competence, attitudes and values, enabling them to be effectively involved in sustainable development at local, national and international levels, helping them to work towards a more equitable and sustainable future. In particular, it enables students to integrate environmental considerations into economic decision-making. For example, when students understand that buildings, not automobiles, emit most of the CO<sub>2</sub> in the US and that the average house is 45% bigger now than it was 31 years ago (Montoya, 2009), they can begin to understand the role they play in environmental sustainability. In order to make such information accessible and relevant to students, it is imperative that academics in engineering, construction, education, and other disciplines heed the call for sustainable technologies, policies, and practices.

## **GENERAL KNOWLEDGE OF SUSTAINABLE DEVELOPMENT**

Over the last three decades, global attention has focused on the concept of sustainability, and sustainable development has been introduced to address and overcome causes and effects of human activities' increasing negative impacts on environment. Parallel to the global trend there is an increasing demand in both the public and private sectors in the US, to understand sustainable design and construction practices. This demand is driven by the realization of the need for sustainable practices that not only help the environment but that can also improve economic profitability and improve relationships among many stakeholder groups (Darwish, et al., 2009).

The sustainable development movement was started after the establishment of "Earth Day", at which point scientists and educators began talking about air and water pollution, toxic chemicals, and hazardous waste (Orr, 1992). The Earth Day Dialogues were inspired by our belief in the need to generate alternative energy and the impetus to drive the movement to place ethics and human values at the heart of the struggle to harmonize the globalization process with sustainable development. The thought was that solutions to those problems are known. Government regulations would limit pollution and require enterprises to use the best available technology to reduce it, thus including the costs in the price of goods. The more we learned, the more we regulated. Twenty-nine years later, progress made in this effort to address air and water may not be as efficient as it should be, but at least things are not much worse than in the 1970's. Still, there has been a loss in momentum in correcting wrongdoings or finding solutions to the environmental crises created by modern life, (e.g. the production of various consumables, agriculture, and construction. Acid rain continuous to fall and stratospheric ozone has depleted which, in turn, increases the planet's exposure to potentially harmful ultraviolet rays. The loss of biodiversity is accelerated as we see the decline or extinction of many birds, bees, fish and insects. The finite of resources such as water and oil is becoming increasingly pronounced. Human activities are altering its basic chemistry and biology on a very large scale and at an increasing rate.

According to the United Nations (2009), there are 6.7 billion humans on earth and the number is expected to rise. From the time that measurement began, the level of carbon took its largest jump at three parts per million in 2006 (Kibert, 2008). Human and environmental health is 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, operation, and maintaining of buildings and infrastructure. Buildings draw one-sixth of the world's fresh water, use one-quarter of wood harvest, and expend two-fifths of its material and energy flows (Gottfried, 2005). 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. Structures also impact areas beyond their immediate location, affecting watersheds, air quality, and transportation patterns of communities (McKeown and Dendinger, 2002).

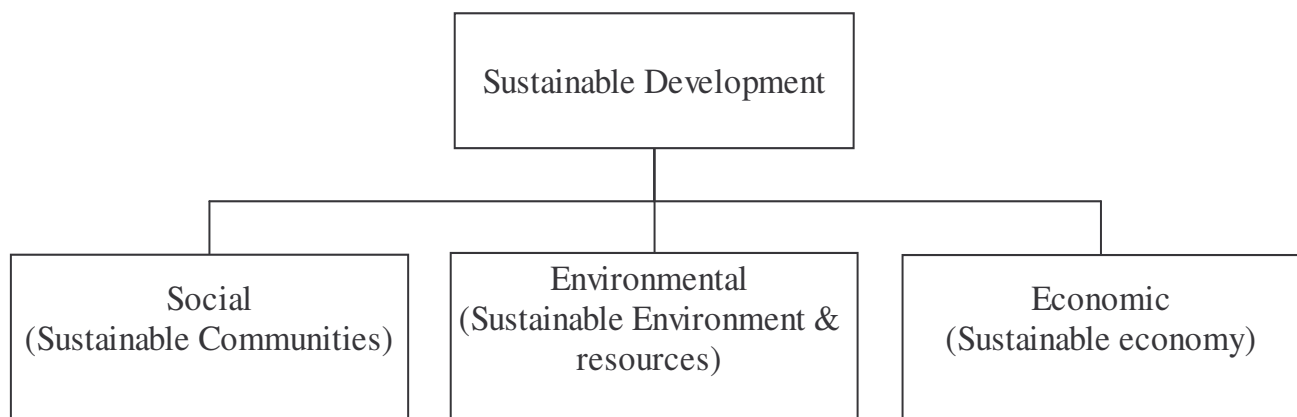
To approach finding solutions to the ecological problem as it has been in the past, technological fixes and single solutions for single problems have been tried. Such efforts do not do enough. Instead, what is required is a fundamental change in the way we meet our needs and a reassessment of what those needs really are.

The challenge of 21<sup>st</sup> century requires that we make a transition to a new order of things that can be sustained. Given the impact buildings have, it is arguable that single most important transitions must be in the building/construction sector. The concept of sustainability in building and construction must focus not only on limited resources, especially energy, and on how to reduce impacts on the natural environment, and technical issues, building components, materials, construction technologies, and energy-related design concepts but also ethics and human values of the occupants of buildings.

## DEFINING SUSTAINABILITY

Sustainability, as defined in the Brundtland report of 1987 (also known as *Our Common Future*), is development “that meets the needs of the present without compromising the ability of future generations to meet their own needs.” 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. Sustainable development comprises of the three broad themes of social, environmental, and economic accountability, often known as the ‘triple bottom line’ (Parkin, S., 2000).

As shown in Table 1 and Figure 1, sustainability is the interaction and connection between society, the environment, and economic/industrial development.

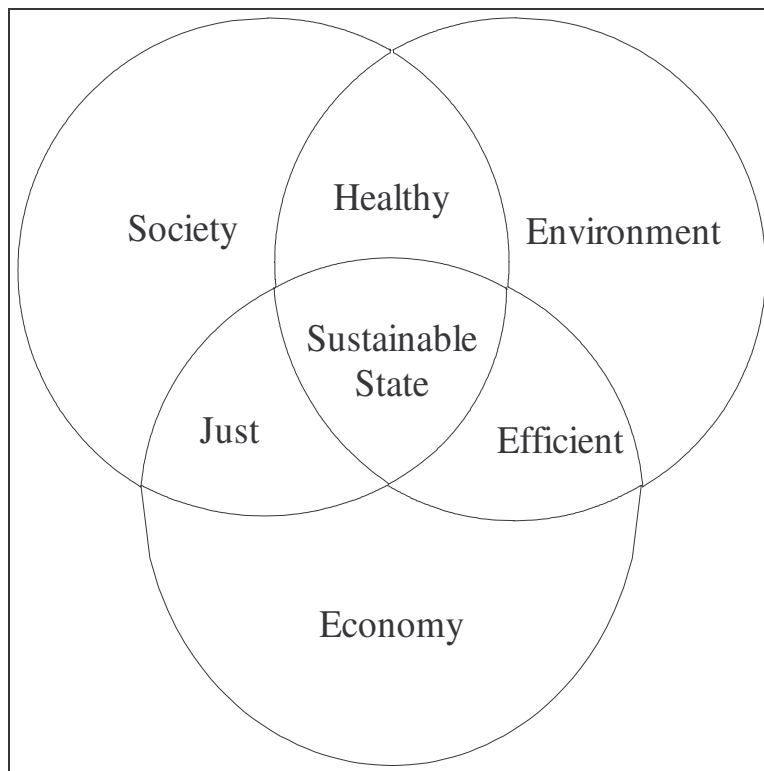


**Table 1. Three basic concepts of sustainability [Darwish et al., 2009]**

## DEFINING SUSTAINABLE CONSTRUCTION

Consistent with the *sustainable development* concept, sustainable construction may be defined as application of sustainable practices into the construction industry including design and construction (Kibert, 2008). Figure 1 provides an interaction diagram whereby the sustainable stage can be reached. Consistent with social, economical and environmental aspects of sustainability, informed 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 good economical sense with regard to environmental impact. It is expected that this trend will continue to accelerate, as 99% of federal and state buildings are expected to be green built. Furthermore, individual owners are intent upon raising the standards of existing buildings with green renovation to bring them up to sustainable state specifications.

As emphasized in the above statements, in order to achieve sustainable development in general among both industrialized and developing countries, interrelationship of social, environmental and economic aspects of the built environment also must be realized. However, without an adequate understanding of how societal and industrial actions impact the environment in which we live or how today's activities may impact the future ethical decision-making is not possible. Therefore, general contractors/managers and engineers of the future must be educated to have better understanding of sustainable development and ethics. They should be equipped with up-to-date knowledge and skills to be able to manage any uncertainties that may arise and make judgments on the available evidence in the built environment design and construct. To help address this need for education engineering colleges will need to implement sustainable development and construction courses into their curricula so that students will be educated and equipped with the required knowledge, creativity, and critical thinking skills.



**Figure 1. Interaction of three basic pillars of sustainability concepts. [Darwish et al, 2009]**

SUSTAINABLE CONSTRUCTION

Sustainable construction may be defined as systematic application of sustainable practices into the construction industry including design and construction (Montoya, 2009). Sustainable building is a rapidly growing practice in new construction development in the US as the green development movement has been adopted by engineers, designers and builders, particularly in urban areas (Leffers, 2010). In Figure 1, Darwish et al (2009) indicate the interconnectedness of a healthy society, economy, and environment that in the ideal sustainable state is both just and efficient.

## **GENERAL KNOWLEDGE OF ETHICS**

Despite daily exposure to ethical issues and beliefs, defining “ethics” as a formal activity can be difficult. This difficulty is only exacerbated with the recognition that so-called “ethical-decisions” can vary widely among people and between societies. This problem, to an important extent, applies to professional ethics as well. All of this implies that while there is a high level of exposure to ethics, it does not follow that people are effective decision makers regarding important ethical issues.

‘Ethics’ might initially be defined in two ways; first, ethics refers to well-based standards of right and wrong that prescribe what humans ought to do, usually in terms of rights, obligations, benefits to society fairness, or specific virtues. Secondly, it refers to the study of development of one’s ethical standards (Velasquez et al., 1987). It is important to take into account the distinction between morals and ethics, ethics being practical reflection of some moral values. Morals refer to generally accepted standard of right and wrong in society, often learned during childhood, but ethics are learned at the time of confrontation of the problems. ‘Ethics’, by contrast are learned at the time of confrontation of the problems. Ethics as field of study is universal but perception of ethical correctness differs.

Moral and ethical statements also must be distinguished from laws; the fact that an action is legally permissible does not always entail that it is ethically permissible. Here is an example of the difference. Suppose an engineer discovers that her/his company is emitting a substance into the atmosphere that is not currently regulated by the Environmental Protection Agency (EPA) and she/he later finds out that this substance may cause harm to human health. Should she/he reveal this information to the EPA? Whatever our views might be in this case, it is clear that emitting this substance may be legally permissible but it appears that it is not sound behavior to do so.

The American Society of Civil Engineers (ASCE) adopted a code of ethics in 1914. The adoption of the ethics codes was part of the professionalization of engineering, an assertion of the profession's autonomy, and the privilege of self-regulation (Little et al, 2007). Since that time, many American professional societies in engineering have adopted their own codes and updated them from time to time, as the context of professional practice has changed. In addition to these specialty specific codes, there is also a shared code of ethics for professional engineers (ABET, 2007) and the state board codes serves as similar function.

## **ETHICS IN CONSTRUCTION ENGINEERING EDUCATION --TEACHING SUSTAINABLE DEVELOPMENT: IS IT NECESSARY AND WHY?**

Construction engineers will play a critical role in building our future; therefore, all the education they will receive is critical (Koehn, 1992; Herkert & Viscomi, 1991; Rojas & Mukherjee; Vesilind, 1987). In addition to the technical aspects of construction, engineers will also need to develop

competence on the ethical issues they will face. One effective way to accomplish this latter goal is to expose engineers to environmental ethics, a branch of applied ethics.

Environmental ethics relates to the relationship between humans and the environment and is defined as a system of ethical values, human reasoning and knowledge of nature which endeavors to forge patterns of right conduct towards environment. These patterns are necessary so that needs of living beings of the present generation are fulfilled without compromising the ability of the future generation to meet their own needs (McDonough et al., 2002). Environmental ethics is relationship between humans and the natural environment they live in. It is the area of study that can teach important information about the responsibility of academia to educate future decision makers in the area of environmental ethics so they will become more confident when standing up for their own opinion or resisting outer pressure if needed. Construction engineers may improve their critical thinking with a background in environmental ethics when decision making arise.

#### **IMPLEMENTATION OF SUSTAINABILITY PRINCIPLES AND ETHICS IN CONSTRUCTION ENGINEERING EDUCATION**

Wise at al., (2004) conducted a four-year longitudinal study of the intellectual development of undergraduate engineering students. They concluded that students need active learning and team-based projects in order to progress adequately in terms of intellectual growth. Moreover, successful integration of sustainability principles and methods into engineering curricula requires a systemic change in our approach to education and societal values.

Integration of principles of sustainability into engineering curricula requires commitment of educators to facilitate the intellectual development of students. King's (2000) research indicates that intellectual development can promote social and cultural awareness among individuals and supports sustainable thinking. Furthermore, by developing critical thinking in engineering students, the next generation of professionals may be more likely to give consideration to issues related to social equity, biodiversity, and the environment (McMasters et al., 2006). Two approaches may be employed to incorporate sustainability perspectives into engineering curricula such as the Center approach or the Whole curricula approach (Darwish et al, 2009 a,b,c). The Center approach requires more resources and more commitment from administration (Darwish et al, 2009 a,b,c). The Whole curricula approach can be employed by designing new curricula which will integrate more sustainable-green perspectives, cultivating sensitivity to the environmental, biodiversity and sustainability issues in students in all engineering disciplines.

Not surprisingly, current engineering ethics education is approached differently by different universities. For example, some universities offer complete specific courses on ethics while others opt to include an ethics component in technical courses. However, it should also be noted that a number of universities do not explicitly and formally address ethics at all. Even where stand alone engineering ethics courses are offered, these are not always required and thus significant portions of students pass over this elective in favor of others. Moreover, some courses suffer from either an excessively theoretical approach or from an unbalanced case-oriented approach. Often times, ethics discussions include a survey of the range of ethical issues facing engineers. While educationally valuable, this approach does not always permit an in-depth consideration of certain facets of an engineer's obligation. Such is typically the case with the intersection of engineering and environmental ethics.

There is a need for implementation of environmental ethics into construction engineering education in such a way that the students will be develop critical thinking that would make them more aware of their actions and decisions. All engineering students must be exposed to environmental ethics,

with a suitable combination of theory and practical applications incorporated into the existing courses. Decision making case studies specific to construction engineering are a practical way of teaching environmental ethics, with lectures and weekly workshops among possible delivery vehicles (Lankford, 2004).

#### CASE STUDY

The Texas Tech Construction Engineering program integrated sustainability into the curriculum with the consideration of an interdisciplinary vision of the construction industry in need of development. The CONE 3304 and CE 5331 “*Introduction to Green Development and Construction Course*” at the undergraduate and graduate level offered in spring 2009 and 2010, are the first courses in the College of Engineering at Texas Tech University to be offered to educate students in sustainable development and green construction principle. As stated in the National Society of Professional Engineer’s (NSPE) Code of ethics, to hold paramount the safety, health and welfare of the public is the first fundamental canon, as well as the number one rule of the practice (Rowden and Striebig, 2004). CONE 3304 and CE 5331 include environmental ethics in the syllabus and great emphasis is given to safety, health, and welfare of the public and environment in the design and construction of building systems.

Yet, more ethics and sustainability are now being taught in the Construction Engineering 3304, (Introduction to Green Development) and Civil Engineering 5331 (Introduction to Sustainable Development and Construction Practices) classes. Topics covered include ethics, environmental ethics, respect of nature, protecting the rights of the non-human and human world within the realm of land ethics, deep ecology principles, and liberation from the West’s excessive appetite for non-sustainable built environment. An emphasis is put on differentiating between industrial ethics and environmental ethics. Students accept that we are part of nature and must focus on quality self- and professional conduct. Stewardship informs the “good engineer” concept that we embrace. Basic concepts, including ecology and ethics, are discussed in the contexts of the environmental crisis as a crisis of mind and spirit. Part of the curriculum demands that students understand and apply their learning to the idea that humans must be part of the ecological big picture; thus, whatever we design and build must be consistent with these principles. Sixty percent of the students who took these classes develop attitudes, dispositions, and skills necessary for the next generation of construction and civil engineers. Others get caught up in the politics of status quo practices and do not see through them in order to transform their own vision and future practices.

Other efforts to teach ethics at Texas Tech University occur in the Murdough Center for Engineering Professionalism (MCEP) and the National Institute for Engineering Ethics (NIEE). MCEP serves as an ethics resource for both the Texas Tech College of Engineering and the engineering community as a whole. MCEP offers an on-campus engineering ethics course for both undergraduate and graduate students. Students from a variety of engineering disciplines routinely enroll in this course. Additionally, the MCEP offers distance learning courses to undergraduate students from other universities as well as professional development courses in ethics for practicing engineers. Thousands of students have enrolled in these distance learning courses through the years. In concert with NIEE, the MCEP has also produced several videos that highlight a variety of ethical issues that arise in the practice of engineering. This resource, coupled with innovations in Texas Tech’s Construction Engineering program, can provide important guidance for the development of an effective and substantive environmental ethics education model for construction engineers.

## CONCLUSION

A building's negative impact on the environment can be reversed or minimized by adopting sustainable green engineering concepts for designing and constructing buildings. Improving the knowledge and understanding by construction engineers and graduates of related disciplines of sustainability and GREEN construction techniques and systems could lead to significant improvements in the environmental performance of the construction industry.

Academic institutions can contribute to the acceptance of sustainability in the construction engineering profession by introducing students to sustainability, along with well-established design constraints like economics, ethics, and ecological literacy.

Social responsibility is not a new issue for the engineering profession. It is fundamental to defining engineering as a profession. Today, part of an engineer's social responsibility is affecting public policy, and the engineering profession is challenged to help define social responsibility as part of defining the principles and practices of sustainable development.

Construction engineering programs have a unique opportunity to contribute to defining sustainable development in the practice of engineering. For this to occur, linkages among social responsibility, sustainable development and the common good must be explored, ideally in a multidisciplinary environment. Further, construction engineering programs need to infuse these topics into their undergraduate, graduate, research and outreach programs; this is part of their social responsibility.

Successful integration of sustainability into engineering curricula demands a change in the approach to education. While a number of universities have started to successfully implement sustainability concepts and principles into their curricula, more work needs to be done to address environmental ethics in construction.

A large demand exist for engineers to understand environmental ethical issues that will occur during their careers, especially given that construction engineers are the ones making decisions about the built environment. Engineers have to stand up for their position in ethically questionable cases. Delivery of theory and practical information combine teaching environmental ethics and case studies can greatly value construction engineering students helping them to make connections shown in Figure 1.

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