AC 1998-543: Sustainability in Environmental Engineering Education

M. Wayne Hall,

Marilyn Barger, Hillsborough Community College

Sustainability in Environmental Engineering Education

Marilyn Barger, M. Wayne Hall
Civil and Environmental Engineering FAMU-FSU College of Engineering

ABSTRACT

More than a decade has passed since the Brundtland Commission report, *Our Common Future*, and six years since *Agenda 21* and the *Rio Declaration on Environment and Development*. Those documents recommended that, to insure a healthy and habitable environment for future generations, the world's businesses, industries, governments, and individuals should adopt and work towards a goal of *Global Sustainability*. The years that have passed since these documents were released have produced some movement towards this goal. Many observers, however, have considered this progress as too slow and too meager. This situation has changed somewhat during the recent past, with concrete examples of attempts to address Sustainability issues, in academia, government, and industry, beginning to emerge. A special case of such emergence is found within today's institutions of engineering education . Engineering is by definition a discipline that focuses on the betterment of human existence through the development and application of technology. It also manifests itself in a wide spectrum of disciplines. These attributes match closely certain characteristics of Sustainability. Thus it seems that, if the concepts of Sustainability are to become an important part of world culture, they should and must take roots in engineering education. This is beginning to happen. Considering the importance of Global Sustainability in light of the responsibilities of one generation of engineers to succeeding ones, however, makes clear the need for those engaged in engineering education to give their full attention to two questions, e.g., "*What is being done*, and, *What should be being done in engineering education, to address the issues and incorporate the ideals of Sustainability into the education of young, new engineers*?"

There are several ways that the concepts of Sustainability can be brought into civil and environmental engineering education. At the institutional level, the engineering colleges themselves can make the conscience decision to carry out their operations in a sustainable manner, and follow up by aggressively implementing that decision. In addition, practices supportive of Sustainable Development can easily be incorporated into the philosophy of all civil and environmental engineering curricula as one aspect of their global goals and objectives. Finally, the ideas of Sustainability can be integrated into classroom material as a constant backdrop for design development, as well as a ubiquitous and important constraint in all types of problem solving and project development.

This paper will review examples of these various modes of incorporating Sustainability into the fabric of civil and environmental engineering education, in the context of engineering history and philosophy. It will tie these to modern engineering professional practice in government and industry aimed at achieving a more Sustainable way of life.

INTRODUCTION

If one poses the question, "*What are we doing in engineering education, to address the issues and incorporate the ideals of sustainability into the education of young, new engineers?*" the answer turns out to be, "*Academic engineering programs in the United States, like many of the nation□s other important institutions, are doing a lot towards developing and implementing plans and programs that have Sustainable Development at their core.*" For example, in March 1998 the Presidential Council on Sustainable Development (PCSD) is publishing a comprehensive report on the status of this concept in the U.S., along with recommendations, action plans, strategies and implementation plans. The document will cover all aspects of society, including industry, education, transportation, and agriculture.(1) In addition to this forthcoming document, the PCSD has already published several related documents, most of which can be obtained from the World Wide Web (http://whitehouse.gov/PCSD).

State and local governments also are making commitments to Sustainability. Having started with the "sustainable" act of recycling, numerous communities are now reaching out to incorporate sustainable policies in many of their local affairs. There exists a profusion of information about recent community commitments, local projects, formulas and implementation plans available on the Word Wide Web that can be found on the PCSD home page listed above.

Neither is industries being left behind in the move towards Sustainability. Once industries, large and small, realized that implementing green ideas could result in significant financial rewards, they began to do so. In recent years, they have continued to increase investment in the such areas as pollution prevention, waste minimization, zero discharge, energy and resource conservation, and life cycle accounting.

In this regard, industry often has proceeded in step with professional organizations, especially those of engineering, science, and technology, which themselves have become very active in the cause of Sustainability. These organizations, for several years now, have been quietly establishing task forces and committees, issuing white papers, reports and public information documents related to Sustainability, as well as offering consulting on the subject to industries, communities, institutions, and businesses. For example, the American Association of Engineering Societies (AAES) has produced a book, *The Role of Engineering in Sustainable Development* (2), and related public education video material that reinforces the argument that Sustainability and Sustainable Development should be at the core of all engineering design processes. The American Society for Testing Material (ASTM) is making final a *Standard Guide for Implementation of a Sustainable Development Program.* (3)

With respect to education and academic entities, the federal government has recommended changes in formal educational systems to incorporate the many aspects of Sustainability, as an import-ant common thread, into and throughout all curricula from elementary to post-baccalaureate levels. Educational objectives contained in these recommendations are couched in terms of such broad ideals as:

- making an awareness of, and knowledge and understanding of Sustainability, a part of the

mainstream consciousness; nationally and internationally
- engaging everyone, at all levels of society, in the quest for Sustainability
- fostering skills, attitudes, motivation and values that will direct actions to Sustainable practices
- developing a universal commitment to work together for a Sustainable future.

These recommendations emphasize that the educational process must be become lifelong, that there must be a connection between the formal and non-formal educational sectors, and that inter-disciplinary studies, hands-on practice, community work, and system thinking are vital to implementing Sustainable practices. The specifics of *how* and *what* and *where* to implement these changes in educational systems are left to the governing bodies.

Of course, it is easy to say that the educational process must include these ideas, but more than difficult to arrive at a consensus about how and when to implement the changes required. Someone has to study, create, evaluate and transfer the new material to educators. For a topic that must be woven into every discipline and every grade level, this will be an awesome task.

ENGINEERING EDUCATION

For many years, the philosophy and framework of engineering and technology educational programs have been defined and articulated by the Accreditation Board for Engineering and Technology (ABET). Necessarily, ABET has changed its accreditation philosophy and requirements have changed over the years to reflect the changing needs and desires of society. To this end, ABET has recently drafted its most radical change in the history of engineering education accreditation. This new criteria, ABET's *Criteria 2000*, will be completely in place by the turn of the century, after more than a decade of careful development. Criteria 2000 is based on the concepts and philosophy of Total Quality Management (TQM). It, therefore, allows engineering academic institutions to establish their own goals and objectives, and determine how they will achieve, evaluate and continuously improve their stated goals and outcomes. One global objective of every quality organization is to be in a mode of continuous improvement. In this last decade of the 20th century, this means that quality establishments, including academia, should be working to weave the principles and practices of Sustainability into every aspect of their organization.

In the context of Criteria 2000, the word "*Sustainability*" itself is not found, nor would its presence be expected. The quality management ideas are in themselves an indication that ABET has attempted to make these new criteria themselves Sustainable, i.e., by making them broad, flexible, and thus potentially meaningful in a variety of spatial and temporal environments. In other words, Criteria 2000 provides a wide umbrella under which each of engineering s academic units can establish their own goals and objectives. Or, as it has been put by one ABET spokesman, "*Thus, when industry, government, students, etc. indicate to an engineering program that sustainable development should be addressed, the institution and faculty find themselves in the position of being responsible for responding to this need under EC 2000."* At a more tangible level, the responsibility to respond to the needs of society is one of the eleven (11) Criteria 2000 outcomes expected of programs graduating engineers. Academic engineering programs must graduate engineers "*who have the broad education necessary to understand the*

impact of engineering solutions in a global/societal context and a knowledge of contemporary issues."

Additionally, Criteria 2000 requires that engineering programs gather feedback from the programs' constituencies and document how they have responded to such feedback. In the interest of fairness and complete coverage of the subject, each engineering discipline has a subset of program criteria, specific to each field developed by practicing professional engineers, and offered by the academic community. To date, none of the more than twenty (20) specific engineering program criteria directly include a reference to Sustainability or Sustainable Development. In broader context however, inclusion of the requirement that engineering graduates produced by all such programs must be aware of and sensitive to the needs and desires of the local and global communities implies a strong concern with sustainability issues.

A few engineering colleges and individual departments have come forth and made Sustainable Development an integral part of their organizational structure and/or curriculum content. The early players in this respect have been programs that interact intimately with the environment and the development and/or management of natural resources. These include environmental, mining, civil, construction, and similar engineering disciplines.

In 1997, the *Australian Academy of Technological Sciences* issued a comprehensive report to its national government on the status of scientific and technological (including engineering) education with respect to its focus on sustainability. It not only reviewed and evaluated the current state of science, technology and engineering education, but also made important, strong recommendations for changes in curricula and program content, context, and continuity. In addition to specific recommendations for science education, a large portion of the document posed recommendations and implementation plans for changes to all disciplines of engineering education.

To produce engineers with a Sustainable mind set, engineering education must allow for more environmental topics to be taught in all disciplines. These topics provide essential background and knowledge for sustainably sensitive design or development, and will provide the basis from which sustainable societies can be produced. Such topics should include: population dynamics, basic biology, the chemistry of natural systems, the fate and transport of pollutants in the environment, natural resources management; public health, and risk assessment.

Studies in these environmental sciences provide the basis from which engineering students can be taught how to build Sustainable Resource management constraints into designs by applying resource conservation technologies such as waste prevention and minimization, zero emission discharge, the use of alternative resources and approaches, and clean production. They also can be used to teach the rationality of including sound, conservative, environmental management in all design projects, of designing with and for the environment, by the application of environmental economics and law, the evaluation and consideration of a project's environmental political and social impacts, life cycle analysis, and the derivation of knowledge-

based alternatives.

The Australian Report (4) recommends that, in addition to such relevant technical matters, all engineering students are taught to consider and evaluate:

- *constraints on consumption of limited resources*
- *recycling of any non-renewable resources*
- *assessment of alternative resources (including man-made resources and development)*
- *evaluation of alternative approaches for utilizing resources*
- *consideration of the transfer from industrial to a knowledge based economy*.

If the goal of Global Sustainability is to be met, all the disciplines involved in Engineering Education must play a strong role in providing a basis for a new, transformed worldview. They must be about the business of preparing ". . . *young engineers to accept sustainability as a basic design requirement for the development of products and processes and as a basic policy criterion for future industrial developments.*" Additionally, it must ". . . *create a general awareness of the need for sustainability within the profession.*" This will require ". . . *the development and updating and continuing education programs with an emphasis on a technology that is in harmony with the environment and that is adapting the profit principle to this situation*." (4)

CIVIL AND ENVIRONMENTAL CURRICULA

In the United States, engineering colleges and departments are at work to make Sustainable Development an integral part of their organizational structure or curriculum content. In today's engineering classrooms, Sustainability surfaces regularly in many introductory environmental engineering courses, which is a requirement for most civil engineering degrees. Additionally, many established upper level courses that have been changed to focus on Sustainability in the context of their original topic.

These introductory courses could provide a strong foundation in the principles of Sustainability, from which other parts of the curriculum, within the context of existing courses, could build or strengthen their own use of such concepts. In the curricula of the future, there also must be a course or courses that has some aspect of sustainability (pollution prevention, zero emissions, life-cycle costs, etc) as its core concept. Several courses of this nature now exist as technical electives for senior engineering students at some universities, including *The Georgia Institute of Technology*, and *The Pennsylvania State University*.

An inventory of topics and concepts that would fit under the heading of *Sustainability* would seem to include, on first examination, all topics related to the environment. This realization begins immediately to relieve some guilt about this matter, because most engineering colleges have courses in environmental engineering, engineering geology, and energy and power production. However, for the most part, existing courses in the environmental area, no matter what department they are in, do not relate the course material to the perspective, pragmatism and philosophy of Sustainability.

For example, Environmental Management is a topic that is often introduced in introductory environmental engineering courses. This topic typically revolves around precepts of environmental impact assessment, a commonly used tool to evaluate the impact of potential projects. The objective of this assessment is to enumerate and quantify changes in the environment that might occur during the project's construction, development, operation, closure, and post closure periods. Impacts during any of these phases might include noise, visual distraction, air, water or ground pollution, social, economic, and even cultural issues. Most governing bodies also require that at least two viable alternatives to the desired project be evaluated in the assessment document. The comprehensive document then is published for public comment, and reissued with public comments and responses included, before being accepted. The process hopefully allows sufficient time to make the best decision for the constituents and stakeholders. This is a fairly easy idea to get across to college environmental engineering students. However, in the Environmental Management course classroom, two major weakness to commonly used civil and environmental curricula are revealed. First, the ideas of environmental management are often taught only *in the context of environmental engineering courses*, and may be addressed only once in students'' curricula. Instead, this introduction should be just the first of many times that they are required to face these important and difficult issues. Second, the scope of many environmental impact assessments falls short of ensuring a Sustainable project or solution, and commonly they do not emphasize the more difficult concepts of risk. Ultimately, these ideas should be integrated into the design aspects of all courses, because, to encompass Sustainable Development, the assessment must evaluate a project's impact from a broader perspective, and on a longer time scale than those of the current stakeholders.

However, education for Sustainability and Sustainable Development cannot be compartmentalized into one course. There is certainly a place for it in many aspects of Civil Engineering including, material selections for projects, site selection, planning and development, traffic and transportation planning, facility size and location, water and related resources evaluation, infrastructure rehabilitation, stormwater control and treatment and discharge, conservation of energy and natural resources, to name a few. The more difficult question is just how to integrate some Sustainability concepts into *each* of these courses, without relinquishing the course's (and the instructor's) sacred technical information transfer. The solutions are too many and too varied to list here. Suffice it to say that some dedicated and creative engineering educators have already undertaken this task.

SUMMARY

Engineering, its academics and its professions, are of particular concern in the pursuit of a Sustainable world culture. Engineering is an important, integral part of modern culture, manifest in a wide spectrum of disciplines, ranging in technical content from the electrons and microchips of the electrical engineer to the agronomics and biology of the agricultural engineer. It is a discipline that always has focused on the betterment of human existence through the development and application of technology. The education and training of new engineers is an

undertaking both broad and deep, as is its practice. All these considerations make engineering education one of the critical places where the concepts of Sustainability needs to become fully integrated into its organizations, its values, and its intended outcomes. It is imperative, therefore, that the ideas of Sustainability should take root in engineering education, and quickly.

Consider that the focus of all University teaching and research still fails to reflect the urgent need for a new understanding of the global ecosystem and humankind's place in it. Consider that funding for all public educational institutions is mired in the politics of less government, lower taxes, and a nostalgia for the values of a world that no longer exists. Consider that engineers and engineering educators are, in most cases, people of technology, and its rigorous application. Consider that the concepts of Sustainable Development look a little "soft" and a little too non-technical to many of them.

Then consider that many of today's collegiate engineering programs are overcrowded, underfunded, and often technically outmoded in a rapidly changing world. Consider that academic reward systems seldom includes incentives for the development of new curricula or course, or for the interjection of new concepts - especially those that appear to be short of technical content - into existing courses and curricula. Now observe that each of these considerations, indeed all of them, have the effect of making it extremely difficult to get engineering college faculty or administrators to focus on making Sustainable Development concepts an important part of engineering curricula and of individual engineering courses.

Consider one more thing. As one thoughtful person has observed,

> "*The conventional wisdom holds that all education is good,*
> *and the more of it one has, the better. . . .*
> *The truth is that without significant precautions,*
> *education can equip people merely to be more effective vandals of the earth*." (7)

That is, a little learning can be a dangerous thing. Can the engineering professions, or the world they serve, afford to continue producing engineers that are not given sufficient precautions concerning the Sustainable workings of earth and its biosphere?

REFERENCES

1. Presidential Committee on Sustainable Development, 1997, *Task Force Report for Public Linkage, Dialogue, and Education*, Whitehouse Publications.
2. The Role of Engineering in Sustainable Development (AAES book)

3. American Society for Testing and Materials, (1997) Draft of *Standard Guide for Implementation of a Sustainable Development Program*

4. The Australian Academy of Technological Sciences and Engineering, 1997, Report by the Joint Sub-Committee on Education and Sustainable Development.

AUTHORS

MARILYN BARGER is an assistant professor in the Civil Engineering Department of the FAMU-FSU College of Engineering where she is developing research programs in waste management, reverse osmosis, and environmental fate and transport. She has a BS in Chemistry from Agnes Scott College and a BS and Ph.D. in Civil Engineering from the University of South Florida. She is a registered professional engineer in Florida and is the current division chair of the Environmental Engineering Division of ASEE.

MILLARD W. HALL is Professor of Civil and Environmental Engineering at the jointly administered Florida A&M University and The Florida State University College of Engineering, in Tallahassee. He has more than thirty years experience teaching, conducting research, and administering environmental science and engineering programs and projects in academia, in government and in the private sector.