AC 2012-5388: ”IT’S JUST GOOD ENGINEERING” ONE CASE OF CURRICULAR EVOLUTION OF SUSTAINABLE DESIGN

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"It's Just Good Engineering" – One Case of Curricular Evolution of Sustainable Design

Abstract

Like most all civil engineering programs, elements of sustainable design have been a part of the learning in Rose-Hulman Institute of Technology's (RHIT) Department of Civil Engineering for scores of years. However, modern sustainable design principles were first evident in the department's course lesson plans in the late 1980's. Assessment of student learning about application of sustainable design principles became a specific criterion of the engineering impact student outcome in the department's assessment plan in 2008.

Results of student work assessment presented in the paper demonstrate that, although students could reflect thoughtfully on sustainability principles, they struggled to demonstrate rational, comprehensive application of these principles to the design process. The evidence suggested a different approach to learning sustainable design was needed. Dialogue with practitioners and industry experts reminded the department that sustainable design is just "good engineering" that has been present in the curriculum for decades. With practitioners' help, the department devised a plan for learning sustainable design across the curriculum.

The paper provides the results of assessment of student learning about sustainable design principles and processes, a simple model for learning sustainable design across the curriculum, and work-in-progress reflection on early findings of the curriculum revision.

Introduction

Economic considerations have always been a part of engineering. At least some social considerations such as aesthetics, safety, and function have also always been part of engineering. Environmental considerations have also been important for many engineers, although some could argue environmental issues did not move to the forefront of engineering until the 1960's and 1970's. Thus, principles of sustainable development have been used by civil engineers for scores of years. Unified commitment to environmental, social and economic considerations under the term sustainable development dates to at least 1986 with the crafting of *Our Common Future*, also known as the Bruntland Report (WCED, 1987). As observed in *Our Common Future*, "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."

Renewal of the commitment of engineers to development that is sustainable was reaffirmed in 1993 by the American Society of Civil Engineers (ASCE) Policy Statement 418 - The Role of the Civil Engineer in Sustainable Development (ASCE, 2010). This was a renewal of commitment by the civil engineering profession. Even the Code of Hammurabi identified over 3,500 years ago the responsibility of builders to their clients, and in 1963 the ASCE Code of

Ethics stated a fundamental canon of its Code of Ethics was the engineer's responsibility for the health, safety and welfare of the public (Vesilind and Gunn, 1998). Vesilind and Gunn (1998) also remind us the 1977 code of ethics included the following statement: "Engineering should be committed to improving the environment to enhance the quality of life." Even so, formally recognizing the commitment for development that is sustainable provided clarity in an area where engineers' ethical responsibilities may have been murky. Most recently, ASCE (2010) has clarified its definition of sustainable development as "…the process of applying natural, human, and economic resources to enhance the safety, welfare, and quality of life for all of society while maintaining the availability of the remaining natural resources."

So the best engineering design, construction, and management has always taken into consideration the economic, social and environmental implications of the work. Even so, 25 years after *Our Common Future*, we find engineers who dismiss sustainable development as something "those environmental tree huggers do" even while they labor to design, construct, and manage economical, safe and environmentally conscious systems. In fact, the engineering of development that is sustainable is just good engineering.

Adoption of a Sustainable Perspective

Because the principles of sustainable development address economic, social and environmental considerations, most any engineering program could claim they have always addressed the principles of sustainable development in their curricula. Certainly, economic considerations almost always inform engineering. Well engineered systems account for the users' safety and satisfaction with the system, thus accounting a little for the social aspect. Environmental engineering is also a part of most civil engineering programs. Although this does not assure that sustainable design is a part of those programs, there would be hope that at least the environmental pillar of sustainable design is present. However, few undergraduate students even today are prepared to demonstrate learning about designs that unify all three pillars of sustainability in a balanced way that also considers community implications, use of cradle-to-cradle materials, favoring local resources, accounting for impacts from an energy perspective, and similar modern sustainable design factors. So the question about when departments first began effectively addressing sustainable design in their curricula is really about when the students began to demonstrate a design philosophy following the intent of *Our Common Future*. For most departments, efforts toward this goal probably correspond to when the department began to have the term sustainable development appear in their courses or curricula.

For Rose-Hulman Institute of Technology's (RHIT) Department of Civil Engineering, modern sustainable design principles first appeared in course lesson plans in the late 1980's shortly after *Our Common Future*. However, at that time, the term "sustainable development" was not used because it was judged by faculty members to be an oxymoron. Sustainable design principles inspired by *Our Common Future* were included in a required environmental engineering course, and students probably associated the learning with this sub-discipline. In the mid to late 1990's,

the department's water resources design course began to include modules on low impact development and best management practices. So sustainable design had by that time infiltrated environmental and water resources course learning. In May of 2002, the department freshman trip included a tour of a green building redevelopment project in Chicago, and in the fall of 2002, learning about sustainable design was adopted into the department's required Civil Engineering Codes and Regulations course. That course was oriented towards guidelines for civil engineering design across all sub-disciplines. The lessons in sustainable design in that class focused mostly on reading and reflection by students, and the only design-focused activity was for the students to conduct a partial Leadership in Energy and Environmental Design (LEED) assessment of an existing campus structure.

Although students were demonstrating sustainable design elements in their senior project work from the late 1990's onward, the term sustainability first appeared in a senior design report in 2004 (Gibson et al., 2004). By the spring of 2005, a few freshman design projects were offered to the students with elements of sustainable design, and a team of students selected and completed a freshman design project for sustainable retreat house for a nearby campus (Camacho et al., 2005). The following year the freshman design projects included a sustainable dormitory for our own campus (Hazard et al., 2006). Through all of these efforts, however, the student body as a whole was not developing skills in sustainable design, even though they were learning about sustainable design. Even the freshman and senior design projects were only partially incorporating sustainable design principles, and there was some doubt among faculty members whether the students as a group generally understood sustainable design.

In the second edition of the ASCE Body of Knowledge (ASCE 2008), the sustainability outcome defined three levels of cognitive achievement for students earning a baccalaureate degree:

1. Students should be able to define key aspects of sustainability relative to engineering phenomena, society at large, and its dependence on natural resources; and relative to the ethical obligation of the professional engineer.
2. Students should be able to explain key properties of sustainability, and their scientific bases, as they pertain to engineered works and services.
3. Students should be able to apply the principles of sustainability to the design of traditional and emergent engineering systems.

In 2008, partially in response to ASCE's recommendations, and partially because of other driving factors, the department formally adopted a sustainability criterion similar to ASCE level 3 under the Engineering Impact outcome:

Outcome:

Explain the impact of engineering solutions on the economy, environment, political landscape, and society; apply the principles of sustainability to the design of engineering systems.

Criterion:

(2) Incorporate sustainability principles in the design of a civil engineering project.

Since then, the department has formally assessed student learning in the area of sustainable civil engineering design. The findings from this and other less formal assessment, along with recommendations from a summer 2011 strategic planning effort, are shared herein.

Assessment of Student Awareness

Beginning in the fall of 2005, seniors in the required Civil Engineering Codes and Regulations class were given an assignment studying sustainable development. They were asked to watch a video by William McDonough (McDonough, 2000) about sustainable development and then to provide a reflection on sustainable development by answering a number of posed questions. This assignment was continued in the course from the fall of 2005 through the fall of 2008 as part of a professional issues segment in the course. Most of the student reflections have been retained and were assessed for this paper with respect to knowledge level 1 of the ASCE Body of Knowledge for sustainability shown above. This assessment of level 1 knowledge for these seniors indicated 74% of the students identified key aspects of sustainability relative to engineering, society or engineering ethics.

In addition to assessing the students' submissions with respect to the ASCE body of knowledge, the students' attitude toward sustainability as reflected in their responses was also assessed. Assessment of attitude is difficult, particularly when based only on written words. However, an attempt was made to assess how much each respondent valued the principles of sustainability, as indicated in the assignments. In this respect, student responses showed that most students either highly valued principles of sustainability (about 45%), or did not value those principles at all (approximately 35%). This somewhat bipolar response may have been due to the character of the speaker, as his style of presentation in that video could be taken as somewhat polarizing for viewers. Noteworthy about student responses, however, was that some students watching the video reported this to be a decision point in their careers. Some of the comments from students in this category are shown below.

This video really got me thinking. It made me realize how careless I can be sometimes, and how serious that really can be. For example, if I alone pour my used oil into the ground it doesn't do as much, but when I do it repeatedly along with several others doing the same thing, it becomes a big problem. Not to just look at my actions in everyday life, but to look at how I should act in the field. It isn't enough to just design something to the specs. The specifications still allow energy inefficiency and chemicals to be put into the environment, but what if I go above and beyond? Instead of designing to the specs, make a more efficient building to conserve energy, or a more efficient wastewater treatment operation.

Sustainable development is a process that civil engineers have been implementing for over 20 years now. With the budding sense of environmental impacts, sustainability has grown increasingly popular since the 1980s. Eventually, this practice will result in structures with

longer lifetimes and less environmental impact. This will allow future generations to enjoy resources that might otherwise have been destroyed. I consider sustainable development to be an ideal resource that we should all be implementing.

I believe that sustainable development is a subject that should be considered in all types of design these days. Ever since freshman design, when our group had to develop ideas for a sustainable house for the nuns at XXMM College, I have become very interested in the subject. Also, just recently, we had to write a paper on sustainable development in Land Development class. The idea of being able to reduce the effects of developing on environment is so intriguing and I can't believe it's talked about more in the engineering business. I like the fact that by studying sustainable development, a designer can design for an environmental friendly neighborhood while also helping that city or town economically… I've actually considered getting into some type of sustainable development after graduation. It's a subject I'd like to further study and hopefully I'll be able to positively impact the environment using my engineering skills in the future.

I truly believe in sustainable development, it is the wave of the future which needs to be implemented as soon as possible. Once I was exposed to this kind of thinking, I was truly transformed into an understanding of a greater good for the world and its people. We need to start to conserve energy and natural resources because of a delicate ecosystem and increasing human population. I believe it is our obligation to design and implement a world we can live in which a symbiotic relationship with our environment can be achieved. This goal is extreme but efforts put in this direction will only benefit ourselves and the generations after us who will continue this mission witnessing the destruction of our ignorant actions to our environment.

Assessment of student awareness through this series of student submissions indicated

- A majority of students were able to identify key aspects of sustainable development relative to a career in civil engineering.
- Most students were either accepting of or highly receptive to sustainable development. Some students were not at all receptive.

Assessment of Application of Principles to Design

Since 2008, the department has assessed students' ability to incorporate sustainability in the design of a civil engineering project. Unfortunately, formal learning did not include specific guidance on how to incorporate sustainable design. Despite minimal guidance, students attempted to incorporate sustainable design, when appropriate to the project. Student submissions to this outcome consisted of senior design project reports. All teams were directed by course instructors and coaches to incorporate sustainable design into their projects, so all projects were to have contained some elements of sustainable design. Teams of four industry experts assessed the team reports during the first two years to identify whether the student work satisfied the learning outcome to a level expected of a graduating senior. During the third year,

teams comprised of a faculty rater and an industry rater rated individual submissions submitted describing how sustainable principles had been incorporated into the students' senior project. The results are shown in Table 1.

Table 1. Assessment of Student Submissions Incorporating Sustainable Design Principles

Year	Satisfactory rating/total submissions	Percent passing
2008-09	3/5	60%
2009-10	5/9	56%
2010-11	33/41	81%

Industry experts rating student submissions recommended individual submissions be collected after the first two years' rating because of uncertainty about whether the work presented in the reports was really representative of all students' understanding of sustainability principles. The increased passing rate for the final year of assessment could be due to the nature of the assignment, the change in the assessment team, or due to improved knowledge and application. The assessment team felt strongly that the students were able to better express their incorporation of sustainable design principles in the individual submissions, and believe the results are a better reflection of the students' learning.

Looking Forward

For nearly 25 years, the department has included learning about sustainable design in its curriculum. For nearly that entire time, there has been little assessment to determine whether student learning is meeting our expectations. Recently collected data from senior design project work is somewhat reassuring, but we find ourselves in 2012 still questioning whether our students are effectively learning sustainable design principles in our curriculum. The faculty members understand that seeking development that is sustainable is simply good engineering. Discussions with our alumni suggest those who find themselves involved in detailed sustainable design work are able to meet their client's expectations, but they express a relatively steep learning curve when compared to other engineering knowledge from their course work before graduation. It is reassuring they are performing well in practice, but disconcerting they experienced a steep learning curve in order to do so. We believe we are not alone among other institutes in our current state of baccalaureate level learning about doing sustainable design.

In the summer of 2011, we convened a strategic planning meeting of our department board of advisors to address student outcomes. Improvement of learning about sustainable design was one of the two learning outcomes addressed, and one of our board members invited a sustainable design expert to join us for work on that outcome. During and following that meeting, the department and its board of advisors developed an action plan to address the conduct of sustainable design throughout our curriculum. Specific action items included

- Create a better and more formal implementation of learning about sustainable design for our freshman design course beginning in the 2011-12 academic year.
- Faculty members work to solicit and encourage ASCE service/community projects in sustainable development, with at least one project offered in the 2011-12 academic year.
- Faculty and department leadership investigate an appropriate curriculum for addressing sustainable development, including more formal course work in sustainable design, and find space in the curriculum.
- Faculty members team with industry experts to identify and develop case studies for classroom use beginning during the 2011-12 academic year in sustainable design.
- Faculty members identify and implement earlier and more detailed learning about and assignments to complete sustainable design in the senior design course.

Assessment plans are being identified for all of the above activities so the department can effectively assess the outcome of this effort.

We are hopeful as a department about our progress in our students' learning about sustainable design, and look forward to opportunities to report on that progress in the future.

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