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## **AC 2011-685: UPDATING THE BENCHMARK SUSTAINABLE ENGINEERING EDUCATION REPORT TRENDS FROM 2005 TO 2010**

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# Updating the Benchmark Sustainable Engineering Education Report – Trends from 2005 to 2010

## Abstract

In Spring 2010, civil engineering department heads participated in a workshop on incorporating sustainability into the civil engineering curriculum during the National Civil Engineering Department Heads Conference. This paper summarizes findings from the workshop regarding perceptions, barriers and challenges to implementing sustainability into curriculum and research. During the 2010 workshop, a survey was administered, and the results indicated that faculty interest was significant with 12% of faculty identified as researching or teaching in sustainable engineering. The results from the 2010 workshop were compared with a similar benchmark survey conducted by the Center for Sustainable Engineering (CSE). In 2005, the CSE was formed with a mission to enhance and assist in developing sustainable engineering at universities on an international scale. This collaborative research center between University of Texas at Austin, Carnegie Mellon University, and Arizona State University completed a benchmark survey in 2008 that identified and characterized US institutions' current state of sustainability and engineering curricula. The benchmark results showed more than 80% of the respondents reported some level of sustainable engineering in existing courses. The 2010 survey results showed that for civil and environmental engineering departments, 89% of the respondents reported teaching sustainable engineering courses.

## Introduction

Sustainable engineering interest has been growing rapidly in the past decade. Numerous engineering schools offer courses or programs in this general area, often with local variations to reflect faculty and schools' specialized interests and knowledge. A survey of administrative heads for nearly 1400 Accreditation Board for Engineering and Technology (ABET) accredited engineering programs conducted by the Center for Sustainable Engineering (CSE) found that more than 80% of the respondents (representing roughly 20% of the 1400 engineering programs) reported some level of sustainable engineering content in existing courses (CSE 2008)<sup>1</sup>.

While there is typically consensus on the definition of sustainability through the Brundtland Report, difficulty remains in assessing the scope of 'Sustainable Engineering' since there is a lack of widespread agreement about what applications and methods are included in the field<sup>2</sup>. There is no widely adopted and precise definition of the content or scope of 'Sustainable Engineering.' For the 2005 CSE survey, no definition was provided but a list of example sustainable engineering tools, concepts and topics was included:

- Life Cycle Analysis (LCA)
- Natural Resource Management
- Climate Change
- Design for Environment (DFE)
- Policy and Regulations
- Renewable Energy

- Industrial Ecology
- Economics (excluding short-term cost analysis)
- Green Design
- Material Flow Analysis (MFA)
- Pollution Prevention
- Reuse and/or Recovery of Products and Materials

This list of examples provides a means of identifying sustainable engineering content, although some additions or deletions might be appropriate. For example, biomimicry (engineering design to mimic biological features), geoengineering (engineering formerly natural environments) and industrial symbiosis (beneficial exchanges of industrial waste flows) are all used in sustainable engineering work.

As part of the 2010 national meeting of Civil and Environmental Engineering (CEE) department heads, the authors of this paper organized an afternoon session on education and research practices for sustainable engineering. This national meeting is regularly organized under the auspices of the American Society of Civil Engineers and is open to all civil and environmental engineering departments<sup>3</sup>. As part of the workshop, we conducted a short survey of participants concerning sustainable engineering curricular content in their own departments. We received 64 completed surveys, representing roughly 25% of accredited civil engineering programs. In contrast to the CSE 2005 benchmark survey, our survey was limited to only civil and environmental engineering programs.

### **Results of the 2010 Civil and Environmental Engineering Department Heads Survey**

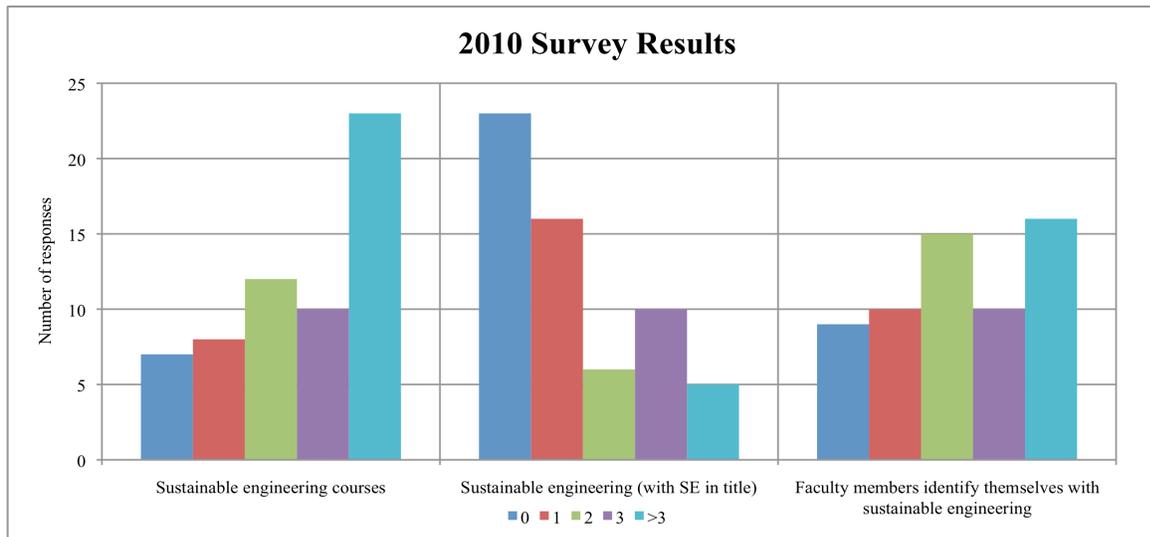
Table 1 shows the results of four survey questions. The average program had three courses with significant sustainable engineering content, while 11% of programs report no sustainable engineering course content. However, only half of these courses were titled sustainable engineering or had a primary focus on sustainable engineering. Faculty interest was significant, with  $2.2/18 = 12\%$  of faculty identified as researching or teaching in sustainable engineering. Only 14% of programs had no full time faculty either teaching or researching in sustainable engineering. Figure 1 shows the numbers of survey responses to the first three questions in Table 1 in graphical format.

A final survey question asked: ‘What barriers do you have in your own department to introducing or expanding sustainable engineering activity?’ Five possible responses were provided and survey participants could select as many as they wished. There was also an opportunity to write in ‘other’ barriers. The response percentages to the five possibilities are summarized in Figure 2. The difficulty of displacing existing curricular material and lack of resources were the most common barriers identified, which is not a surprise. No department heads suggested that sustainable engineering was just a fad, and only a few indicated that other strategic priorities were a barrier. Four department heads (6% of sample) indicated that they had no barriers for increasing sustainable engineering content as this was a strategic priority.

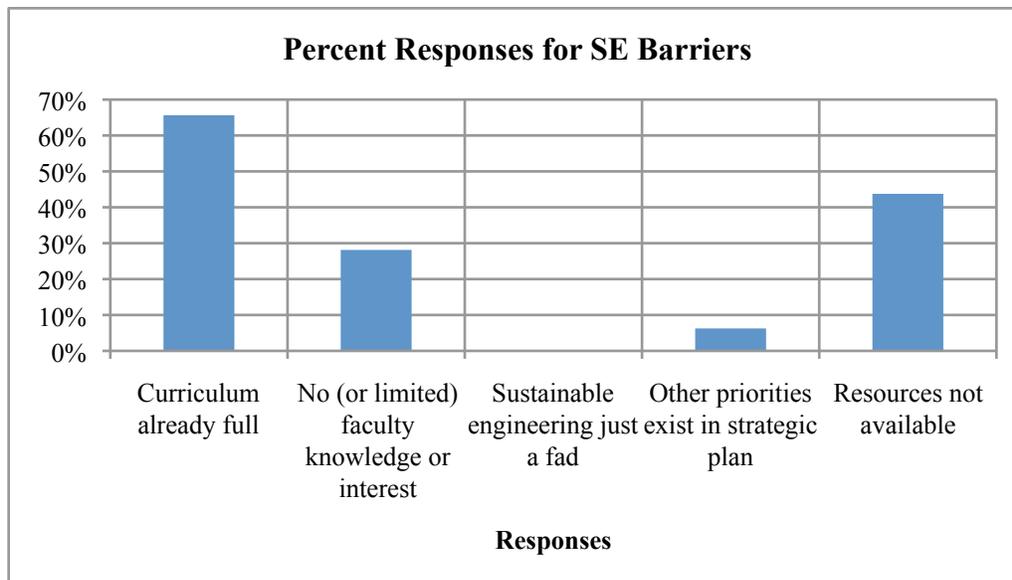
**Table 1: Survey Results of 64 Civil and Environmental Engineering Department Heads to 2010 Survey Questions**

Questions	Average*	Percentage of zero responses
1. How many courses taught in the past two years in your department have significant sustainable engineering content? (0,1,2,3,>3)	2.6	11%
2. How many courses taught in the past two years in your department have sustainability in the title and sustainable engineering as the primary focus? (0,1,2,3,>3)	1.3	34%
3. How many faculty members identify themselves as researching or teaching sustainable engineering? (0,1,2,3,>3)	2.2	14%
4. How many full time equivalent faculty are in your department?	18	0%

\*Average assumes >3 is 4 for calculation, so the actual average may be higher



**Figure 1: Responses from Civil and Environmental Engineering Department Heads 2010 Survey Related to Sustainable Engineering Courses. [0,1,2,3,>3 represent the number of sustainable engineering courses.]**



**Figure 2: Percent Responses from Civil and Environmental Engineering Department Heads 2010 Survey Related to Barriers for Implementing Sustainable Engineering Courses.**

Other barriers cited to more widespread introduction of sustainable engineering into the CEE curriculum included the following responses:

- Need for additional funding for graduate fellowships and faculty lines
- One elective course in 4-year Bachelor of Science in Civil Engineering (CE) program, ABET constraints prevent change
- Getting faculty to agree on reducing other required courses
- ABET
- Tough to define what constitutes sustainability in structural engineering
- Water needs of region tend to dominate public priorities; it is the sustainability issue (location = Nevada)
- Just getting underway. Recently hired a full-time equivalent in sustainable infrastructure. He will teach green building design; next hire will also be in sustainable engineering, but in water/Environment side.
- Budget to revamp curriculum
- Currently deciding "best" way to better incorporate sustainability
- Lack of student demand
- Sustainable concepts are woven into courses, but no specific requirements
- Misunderstand what sustainability is so they do not see the link
- Unable to find ready made lectures for different CE courses, but a revision of the CE curriculum will mitigate this
- Developing implementation into several courses

### **Trends in Sustainable Engineering Offerings: 2005-2010**

In general, the 2010 survey results were compared with the 2005 benchmark results in two major

areas – the percentage of schools offering sustainable engineering courses and number of sustainable engineering courses offered.

One outcome of the 2005 benchmark survey was determining the percentage of schools that were offering courses related to sustainable engineering, so a comparison between the 2005 and 2010 was examined. The 2005 benchmark results indicated that more than 80% of the survey respondents were teaching sustainable engineering courses or integrating sustainable engineering material into existing courses. The 2010 survey results were slightly higher, with 89% of the respondents reporting that they were also teaching sustainable engineering courses. The results, however, between 2005 and 2010 were not directly comparable due to the difference in the survey groups – 2005 survey group was broader with all engineering disciplines represented, while the 2010 survey was civil focused. The 2005 benchmark results for only the civil, architectural, and environmental discipline indicated that about 88% of respondents were teaching sustainable engineering or integrated courses (see Table 5.1 in (CSE 2008)); the 2010 survey results for civil and environmental only were at 89%, as previously mentioned. When a more direct comparison was made, the results indicated that an increase did not occur. However, given that a large percentage of schools were already offering sustainable engineering courses, this result was reasonable.

In addition to understanding the percentage of schools offering sustainable engineering courses, the 2005 benchmark survey also examined the number of sustainable engineering courses offered. A comparison between the 2005 and 2010 results was examined. In 2005, the results indicated that about half (47%) offered at least one course in the last five years with sustainable engineering as a focus. In 2010, the results from survey question two were similar – about 50% of the respondents offered at least one course with sustainable engineering in the title. As a comparison between 2005 and 2010 for offering 3 or more courses, the results were 16% and 19%, respectively. Again, minimal change occurred over five years.

### **Prospects for Sustainable Engineering**

One major outcome from the 2010 survey results was that sustainable engineering interest and expertise remain strong with the majority of the universities offering sustainable courses (89%) and active engagement of faculty (12%).

The 2005 benchmark report stressed the need to move from “grass-roots” activities to a more structured and organized sustainable engineering community. The survey from 2010 did not explicitly address this shift; however, the comments section of the survey and the discussion during the 2010 ASCE workshop generally indicated while there is some structure and organization, the sustainable engineering community still remains in the flux. The general observation is that many universities have and continue to increase the number of sustainable engineering courses but long-term strategy may be lacking.

Various existing professional engineering societies have been actively promoting more sustainable engineering activities. For example, American Society of Mechanical Engineering (ASME) has an annual ‘Sustainable Energy’ conference and the ASME Journal of Mechanical Design published a ‘Special Issue on Sustainable Design’ in September 2010. IEEE also has an

annual ‘International Symposium on Sustainable Systems and Technologies’ which was formerly the Conference on Electronics and the Environment. ASCE has an active national committee on sustainable engineering and recently sponsored a specialty conference on ‘Green Highways.’ Association of Environmental Engineering and Science Professors regularly hosts sustainability sessions at its annual conference.

Specialty professional organizations are also active in this area, such as the International Society for Industrial Ecology and the Green Building Alliance. Interested faculties have numerous publication outlets as a result.

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