

BENCHMARKING THE INTEGRATION OF SUSTAINABILITY INTO ENGINEERING CURRICULA AT US INSTITUTIONS OF HIGHER EDUCATION

by

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Abstract: Sustainability is a multi-disciplinary and evolving concept and practice. It has been defined in a variety of ways in the literature. One of the widely accepted (but by no means completely satisfactory to cover all dimensions of the concept) is the so-called Bruntland commission's definition which defines it "as meeting the needs of the present without compromising the ability of the future generations to meet their own needs." The concept and practice of sustainability has become very important in engineering profession. We conducted a project to determine and unravel the current state of integration of sustainability in engineering education at the colleges and universities across the nation. We focused on identifying several key activities and indicators to conduct the study. This paper will discuss and present the results of this phase of the project.

Background:

The idea of sustainability and sustainable development emerged from the World Commission on Environment and Development (WCED), the so-called Brundtland commission, which defined sustainable development in *Our Common Future* (1987) as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is a multi-disciplinary concept. This proposal strategically harnesses multidisciplinary expertise of various Principal Investigator/co-Principal Investigators. To address the challenges of education and research in the engineering paradigm, the proposed multidisciplinary collaboration between universities, industries, government, and national laboratories is a must.

The proposal solicitation lists the following stated activities and specific areas of interest: “The extent of integration of sustainability into the engineering curricula at institutions of higher education in the United States may be identified by several key activities and indicators including but not limited to: (1) curricula development activities such as new core courses or electives or amending existing courses to include sustainability themes; (2) centers and institutes on campus related to sustainability; (3) conferences related to sustainability developed and hosted by faculty, departments, or engineering schools; (4) institutional support and funding for research relating engineering fundamentals, design, and concepts to their impact on society, economy, and the environment; (5) opportunities to pursue concentrations in sustainability or joint degrees between engineering departments and departments focused on other aspects of sustainability including policy, economics, social sciences, business, etc.; (6) designated faculty with a single or joint appointment whose title, teaching, and research focus on sustainability; and (7) individual guest lectures in courses, department, or college-wide seminars or seminar series focused on sustainability, and faculty networks.”

A computer search was performed using the Compendex and Science Citation Index databases; no citations were identified for benchmarking sustainability at educational institutions, although a number of citations were identified where sustainability has been benchmarked for various industries. Basu and Carabias-Hutter [2004] developed indicators for measuring performance for sustainability assessment, reporting it at local and global levels. The authors note that relevant and credible sustainability reporting supported by a consistent performance indicator can be the starting point for benchmarking environmental and social performance for the natural resources sector.

Gentile et al. [2001] studied ecological risk assessment, sustainability and ecosystem and adaptive management practices and processes used nationally as a decision and policy framework for a variety of ecological assessments. They studies management (societal) actions, environmental stressors, and societal/ecological effects, to provide a basis for developing and testing causal hypotheses. They developed performance criteria for the stressors to assist in the decision making process.

Amarai [2002] reported on the use of sustainability indicators for environmental, social, and economic performance evaluation. Examples were provided for the use of

sustainability indicators, such as efficient use of energy and natural resources and reduction of emissions (in the environmental area), maximization of social benefits of business and involvement of interested parties (in the social area), and maximizing economic benefits of business and inclusion of social criteria in the business decision-making process (in the economic area).

The focus of our research is on developing, designing, and applying “a systematic and comprehensive method to benchmark/evaluate the anecdotal claims about the integration of sustainable engineering into the teaching of university courses” and to draw definitive conclusions about the state of the effectiveness of integration of sustainable engineering in the engineering curricula across the country.

Research Objectives:

The objectives of our project are to:

1. Identify key activities and indicators.
2. Define metrics and develop a methodology to evaluate and aggregate them for engineering departments. Design metrics/rubrics of topics/activities/factors to evaluate the extent and quality of integration (by designing Integration Indices) of SE in engineering academic departments.
3. Design a classification system that can differentiate between academic institutions allowing for accessing information based on institutional characteristics such as discipline, size (number of students), public or private, etc.
4. Conduct the evaluation to benchmark the extent and quality of integration of sustainability into U.S. engineering curricula.
5. Describe a strategy to disseminate the information to the appropriate audiences.
6. Outline a means to identify engineering faculty members, departments, and/or administrators that have significantly contributed to advancing the integration of sustainability into engineering education and raising the level of awareness.

Research Tasks:

These project tasks are listed below.

- Task 1. Perform initial visits with the various engineering professional societies and with the various Federal agencies.
- Task 2. Identify key metrics and develop a methodology to evaluate and aggregate them for engineering departments.
- Task 3. Conduct the analysis and evaluation to benchmark the integration of sustainability into U.S. engineering school curricula.
 - Subtask 3a. Collect information through surveys and develop preliminary metrics.
 - Subtask 3b. Collect information through website database and update the metrics.
 - Subtask 3c. Collect data through site visits and refine the metrics.
 - Subtask 3d. Data compilation and analysis.

- Task 4. Evaluation of integration of SE topics in curriculum with reference to ABET criteria and ASEE Environmental Engineering Division (Sustainable Engineering Section) Guidelines.
- Task 5. Develop complementary activities at UAB, UIC, and University of Wyoming.
- Task 6. Analysis, conclusions, and recommendations.
- Task 7. Dissemination of results and findings.

Results and Discussion

This paper addresses data collected to this point in time under Task 3, specifically under Subtask 3b. A graduate student at UAB has been searching the web to identify universities which are teaching courses in the sustainability area. We have identified universities from 15 states and the District of Columbia which are teaching college level courses in the area of sustainability. The project team is checking on the web and using various databases to determine the courses listed on the university “books” as being taught in their departments, with the goal being to develop a questionnaire/survey to be sent to the department head and engineering dean to identify (a) how frequently these courses are taught, number of students who took these classes, etc., and (b) a copy of the course syllabus and information on the textbook(s) used. This effort requires considerable time and effort. There are about 340 colleges and universities that offer bachelor’s degree programs in engineering that are accredited by the Accreditation Board for Engineering and Technology (ABET), and about 240 colleges that offer accredited bachelor’s degree programs in engineering technology [U.S. Department of Labor and the Bureau of Labor Statistics, 2002-2003]. There are about 14 different branches of engineering: aerospace; agricultural; biomedical; chemical; civil; computer hardware; electrical and electronics (except computer); environmental; industrial (including health and safety); materials; mechanical; mining and geological (including mining safety); nuclear; and petroleum engineering [U.S. Department of Labor and the Bureau of Labor Statistics, 2002-2003]. The websites for each engineering department are being visited to identify the undergraduate and graduate course curricula. This likewise is a fairly time-consuming effort. For example, there are 271 civil engineering departments, 157 chemical engineering departments, 271 mechanical engineering departments, etc., across the U.S. Spreadsheets or qualitative research software (described below) will be developed for each engineering discipline, listing the particular college/university, and listing courses identified on the department website which would pertain to sustainability, pollution prevention/waste minimization, etc. We intend to ask questions to identify whether sustainability concepts are being incorporated and taught in design classes taught in discipline specific (for example, civil, chemical, or mechanical) engineering curricula. The survey questionnaires will be mailed to the various engineering departments for their response; data will then be collected, sorted, categorized, and analyzed. From the information obtained from the websites and engineering database analysis, along with the survey questionnaire, we will identify those universities where a number of departments seem to be teaching classes in the area of sustainability/pollution prevention. The materials collected will help answer the questions “What are appropriate and widely used concepts, tools, and methods of sustainable engineering that are valued by (and taught by) engineering faculty across the nation? and “What are (in specifics) the benchmarking

factors and activities?” The data gathered from the websites and databases, along with the questionnaire responses will be used to select and decide on engineering academic departments and colleges that will participate in the study (after developing a criteria for selection). Input from the engineering professional societies (ASEE, ABET, ASME, ASCE, AIChE, etc.) will also be used in this selection process. Phone interviews will be conducted with selected responding faculty members/instructors/academic instructors; the data from these phone interviews will be collected, compiled, and analyzed.

In moving toward accomplishing this task, we have begun the process of search the web to identify colleges and universities which are teaching courses in the area of sustainability. Results obtained to date are summarized in Table 1 on the following page, for 15 states and the District of Columbia. Inspection of the data presented in this table identifies the following key points:

States Investigated from Web-Based Search (to date):

- Alaska
- Connecticut
- Indiana
- Kentucky
- Maine
- Maryland
- Michigan
- New Hampshire
- New Jersey
- Ohio
- Pennsylvania
- Rhode Island
- Vermont
- Virginia
- West Virginia
- District of Columbia (Washington D.C.)

University Departments Offering Sustainability Courses:

- Agriculture and Life Sciences
- Agriculture, Environmental and Regional Economics and Demography
- Anthropology/Sociology with an environmental studies minor
- Applied Sciences
- Architecture
- Architecture and Urban Planning
- Biology
- Business Administration
- Center for International Programs
- Civil Engineering

- Civil and Environmental Engineering
- Economics
- Environmental Earth Sciences
- Environmental Economics and Policy
- Environmental Engineering and Science
- Environmental Health and Safety Technology
- Environmental Law
- Environmental Management
- Environmental Science/Sociology
- Environmental Sciences
- Environmental Studies Program
- Environmental Theories and Applications
- Forestry and Environmental Studies
- Geography
- Geology and Astronomy
- Global Studies
- Institute of Environmental Studies
- Interdisciplinary Studies
- International Environmental and Agribusiness Management
- Political Science
- Public and Environmental Affairs
- Science Technology and International Affairs
- Sociology
- Sustainable Futures Institute

Summary and Conclusions

Although we have collected some good data that are included in this paper, we are still in the process of collecting more data from different regions of the country. So, this paper is, at this point, a report on "work-in-progress". It is more like an extended abstract. By the time we'd need to submit the final version of this paper, we'd have collected all data that we need and our analysis and conclusions would be complete.

Our extensive review of literature points to the conclusion that in last few years the importance of teaching the methods and concepts of sustainability and "sustainable engineering" in undergraduate engineering curricula has been determined to be of high priority by EPA, NSF, and some universities. What topics of sustainability to include and how to integrate those topics in courses and curricula are still a matter of discussion and debate. The interest of EPA, NSF, and professional organizations on this matter is encouraging in the sense that many engineering departments across the country have started working on some form of integration of these topics. Our data that we have collected so far, is limited in its breadth. Although we covered from Alaska to Kentucky, the gap exists from south and west part of the country. And, we are in process of getting them. Of the data we have if we classify them by disciplines, we find that sustainability has been integrated in engineering and environmental science programs of about 33% of

the universities that we surveyed. Since we do not have data on the course outlines (syllabus) yet, we do not know what topics are being integrated in engineering programs as opposed to non-engineering programs. That would indicate what topics are being valued by the academicians and practitioners of engineering profession and why? That would be very important information in establishing some kind of guideline for a national consensus on topics of sustainability to be integrated in engineering curricula. That is our goal for the final version of this paper, and we would be able to do it in about two months.

Table 1. Data Collected on Teaching Sustainability Courses at Colleges and Universities.

Course Number	Name of Course	University	Department	Instructor	Title of Instructor	State	Academic Year	Frequency of Course	Number of Students Enrolled
SC 440	Tropical Ecology	Alaska Pacific University	Business Administration			AK			
F&ES 757a/ANTH 597a	Sustainable Development and Conservation: Introduction to Social Aspects	Yale University	School of Forestry and Environmental Studies			CT			
291	Civil and Environmental Engineering Professional Issues Seminar	University of Connecticut	Civil and Environmental Engineering			CT			
	Environmental Science/Environmental Studies	Post University	Environmental Theories and Applications			CT			
EES 205	Sustainable Energy and the Environment	Eastern Connecticut State University	Environmental Earth Science Department			CT			
SITA 366	Environment in Africa	Georgetown University	Science Technology and International Affairs	Dr. Marcia Colman-Adebayo		DC			
435	Trade and Sustainable Development	The George Washington University Law School	Environmental Law			DC			
CE556	Sustainable Development Principles and Practice	The Catholic University of America	Civil Engineering			DC			

GEO 260	Environmental Conservation	Valparaiso University	Department of Geography			IN	Spring 2005		
	Natural Resource and Environmental Economics	Purdue University				IN	Fall 2004		
E 535	International Environmental Policy	Indiana University – Bloomington	School of Public and Environmental Affairs	Matthew Auer	Professor	IN			
GEOS 111	Environmental Geosciences	Earlham College				IN			
GSC524	Conservation of Natural Resources/Sustainable Development	Western Kentucky University		David J. Keeling	Professor	KY			
	Political Economy and Environment of Canada	University of Kentucky		Ernest J. Yanarella	Professor	KY	Fall 2003		
Biol.111	Environmental Science	Bellarmino University	Biology			KY			
GSC524	Conservation of Natural Resources/Sustainable Development	Western Kentucky University		David J. Keeling	Professor	KY			
	Sustainable Community Development	Washington College	Environmental Science/Sociology	Wayne Bell/Philip Favero/Wendy Miller		MD			
INDS 430A	Interdisciplinary Studies Seminar Global Society: Prospects for Sustainable Development	University of Maryland-Baltimore County	Interdisciplinary Studies			MD	Fall 2005		
	The Graduate program in Sustainable Development and Conservation Biology	University of Maryland				MD			
BIOL 306	Human Ecology and Sustainability	Towson University	Biology Department			MD			

	Environmental Planning	Frostburg State University	Department of Geography	Dr. Craig Caupp		MD	Fall 1995		
AGM 10601	Introduction to Sustainable Agriculture	Garrett College	Agriculture Management	McCrobie		MD			
	Sustainable Development Principles and Policy	The University of Maine	International Environmental and Agribusiness Management			ME			
PL 4413	Natural Resource Policy	Unity College in Maine				ME	Fall 2005		
321	Ecological Economics and Sustainable Development	Bowdoin College	Economics	Vail, David		ME	Fall 2004		
Urban Planning 532	Sustainable Development - Resolving Economic and Environmental Conflicts	University of Michigan, Dearborn	College of Architecture and Urban Planning	Scott Campbell	Professor	MI	Fall 1999, Winter 2006		
ENG 5510	Sustainable Future I	Michigan Technological University	Sustainable Futures Institute			MI			
	Sustainable Development Studies	Kalamazoo College, People, the Environment and Development	Center for International Programs			MI			
896	Precision Agriculture and Sustainable Development	Lasing College	Applied Science			MI	Fall 1999 - Summer 2005		
ECN 340	Economics and the Natural World	Alma College	Economics	Choksy, Mueller, Cunningham	Associate Professor	MI			

PHIL 450	Ecology and Values	University of New Hampshire-Manchester	Philosophy			NH			
SOC 380	Environmental Sociology	Keene State College	Sociology			NH			
Event	State of the Planet 2006: Is Sustainable Development Feasible?	Franklin Pierce College				NH	March 28 - 29, 2006		
ECON 145	Sustainable Development	Drew University				NJ			
	International Environmental Law and Sustainable Development	Rutger University-Newark				NJ			
4901.138	Issues in Sustainable Development	Rowan University				NJ			
WWS 586e	Global Environmental Issues: Science and Policy	Princeton University				NJ			
	Env. Resources Sustainability	Wright State University	Environmental Sciences			OH	Fall	Once a year	
ASI 373	Engineering	University of Dayton	Engineering	Dr. Kallenberg		OH			
15-041-263	People and Environment Part III: Energy and Mineral Resources	University of Cincinnati	Department of Geography	Dr. Wendy R.Eisner	Professor	OH			
2800:290	ST: Environmental Management and Sustainability	The University of Akron	Environmental Health and Safety Technology			OH			
Geog 111	Introduction to Physical and Environmental Geography	Ohio Wesleyan University	Geography Dept.	J.B. Krygier		OH	Fall 2005		
Supplemental Lecture	Environmentalism	Ohio State University		Stephen T. Abedon		OH	98/05/26		

CRP 724	Planning for Sustainable development	Ohio State University	School of Architecture	Dr. Maria Manta Conroy	Professor	OH	Fall 2004		
384	Comparative Environmental Sociology: United states and Japan	John Carroll University	Sociology			OH			
ENV 553	Environmental Planning 1	Cleveland State University	Environmental Department	Dr. Wendy Kellogg		OH	Fall 2004		
536	Environmental Geology	West Chester University	Geology and Astronomy			PA	2005 - 2006		
GSM 594	Sustainable Business Practices	Temple University		E.D.Weiler		PA			
	Sustainable Development	Susquehanna University	International Studies			PA			
	Sustainable System Seminar	Slippery Rock University		K.E.Schwab		PA	2004		
POL 1051 FS1	Introduction to International Politics/Freshman Seminar	Saint Joseph's University	Political Science Department	Dr. Lisa A. Baglione		PA	Fall 2002		
AG EC 450	International Development, Renewable Resources, and Environment	Penn State University	Agriculture, Environmental and Regional Economics and Demography	Dr. David Abler	Professor	PA			
PHL 304	Environmental Philosophy	Lincoln University	Undergraduate course			PA			
Poli 222	Contemporary Environmental Issues	Mercyhurst College	Department of Political Science			PA			
	Sustainable Development Planning and Practice	Bucknell University	Geography			PA			
90-767	Climate Change, Energy Policy and Sustainable Development	Carnegie Mellon University				PA			

	Business and its Consumers	Rhode Island College		Dr. Shani Cater		RI	FALL 2003		
ECN 335	The Economics of Developing Nations	Providence College	Economics Department			RI			
SOCS 2080	Global Seminar - Man and the Environment	Community college of Rhode Island	Sociology			RI			
135	Environmental Studies	Brown University	Environmental Economics and Policy	Jonathan Harris		RI	FALL 2004		
	Environmental Design	Washington and Lee University	Environmental Studies Program			VA	Winter 2000		
AAEC 4314	Environment and Sustainable Development/ Economics	Virginia Tech University	College of Agriculture and Life science			VA	2005 – 2006		
ENVR 345	Society, Economy & Nature: Global Perspectives on sustainable Development	University of Richmond	Environmental Studies			VA			
ECON 431	Global Environmental Issues	University of Mary Washington	Department of Economics			VA			
POLI 445	Sustainable Development	Regent University	Political Science	DR. Mujde Erten- Unal		VA	Fall 2003		
CE 458/558	Sustainable Development	Old Dominion University	Environmental Management			VA			
ENV 220	Environmental Problems	Moutain Empire Community College		Dr. Chuks Ogonnaya		VA			
ISAT 410	Sustainable Energy Development	James Madison University				VA			

GL 202	Sustainable Development: Case study	Saint Michael's College	Global Studies			VT			
	Sustainable Development	Marlboro College	World Studies Program			VT			
EvNV 3021/ELA 3021	Sustainable Development : Theory and Policy	Green Mountain College	Management and Environmental Studies/ Dept. Business and Economics	Steven E. Letendre	Associate Professor	VT	Fall 2004		
ELCE 491	Senior Design II	Institute of Technology West Virginia University		James Cercone	Professor	WV			
ECON 311	Introduction to Economic Development	West Virginia University at Parkersburg	Economics			WV			
694 EIA	Graduate Seminar in Exploratory Data Analysis	West Virginia University	Department of Geography	Trevor M. Harris	Professor	WV			
EVVS 341	Sustainable Energy and Development	Shepherd College	Institute for Environmental Studies			WV			
ES 620	Environmental Management Systems	Marshall University		Dr. Allen J. Thacker		WV	Fall 2004		
SOC 3404	Sustainability Development	Transylvania University	Anthropology/ Sociology with Environmental Studies minor				Spring 2006		20
	Applied Sustainability	Ohio University					Fall 2003		
ENVR 556	Environmental Policy and Sustainable Development	Air Force Institute of Technology	Environmental Engineering and Science						

***Delaware - No results found**

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