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Special Issue

Sustaining Sustainable Design

Guest Editors

Clive L. Dym—Harvey Mudd College

Janis P. Terpenney—Virginia Polytechnic Institute and State University

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Clive L. Dym	240–246	Sustainability: Affirming Engineering Values

This paper encompasses and extends opening remarks made at a workshop on sustainability and design education by the chair of the workshop's organizing committee. Held at Harvey Mudd College in May 2009, and supported by Mudd's Center for Design Education, Mudd Design Workshop VII provided a forum for engineers and designers—in their roles as educators, researchers, and practitioners interested in learning and in design—to identify and articulate important aspects of sustainability in design and engineering education. The remarks detailed below are intended to remind us, as engineering and design educators, that issues of sustainability are inherent in and central to our professional obligations as engineers.

Keywords: environmental drivers; resource utilization; engineering values

Malcolm Lewis	247–251	Sustainability: The View from a Practitioner's Perspective
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This paper summarizes the author's keynote address to a workshop on sustainability and design education held at Harvey Mudd College in May 2009. The remarks draw upon the author's experience applying sustainable design to buildings and communities over the past thirty years of professional engineering practice. Key points include: the need to include 'right brain' concepts into the study of sustainability; the opportunities for increasing sustainable impacts at a community scale (rather than a single building); the need to incorporate holistic 'closed loop' thinking into sustainable design solutions; and the need to provide today's engineering students with tools and concepts that will enable them to expand the application of sustainability.

Keywords: meaning of sustainability; practice of sustainable design; systemic view

Andrew Lau	252–259	Sustainable Design: A New Paradigm for Engineering Education
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This essay rejects the notion that we understand sustainability well enough to talk about 'sustaining sustainable design'. The wide-ranging literature is surveyed to explore the contested meaning of sustainability. What emerges is an evolution of the meaning, with enlarging scope and philosophical basis, from an environmental emphasis to a focus on human flourishing and caring. A definition consistent with the most evolved view is that: 'Sustainability is the possibility that humans and other life will flourish on the Earth forever.' Ideas are presented about how flourishing can guide design.

Keywords: sustainability; design; education; engineering; paradigm

Bruce Corson	260–264	Sustainable Design as a Sustained Upstream Effort
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A salmon swims upstream to its birthplace—renewing the cycle of its life. The tectonic rise against which it struggles is an unending cycle—of uplift and erosion, of heat and cold. Wishing to catch the fish, a human waits, breathing deeply, quietly—an unending cycle of expansion and contraction, of tension and release. The human's desire itself an unending cycle—of transforming what is to what might be and what might be to what is. This cycle—of certainty and curiosity, of wondering and knowing—we call 'design.' It is another form of breathing.

Keywords: problem-naming; design sensibilities; exploration; design-breathing; pre-expert design; whole systems; whole person

Gaurav Ameta, Jitesh H. Panchal and Charles Pezeshki	265–270	A Collective-Learning Approach to Sustainable Design Education
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This paper discusses our attempts at implementing a collective-learning approach to sustainable design education in the Systems Design course (sophomore/junior level) at Washington State University. The project involves designing a sustainable airplane by different group of students working on different aspects of the airplane. These sub-systems are developed so that from requirements identification to preliminary design each sub-system group can interact with each other creating a virtual-enterprise within the classroom. Sustainability aspects are currently limited to identifying recycling information and creating a Bill of Material for RoHS (Restriction on Use of Hazardous Substances) certification.

Keywords: collective-learning; sustainable design; RoHS; preliminary aircraft design

Micah Lande and Larry Leifer	271–277	Difficulties Student Engineers Face Designing the Future
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Design can change the world. Growing environmental and social concerns about the role we play as world citizens and caretakers of the planet have given rise to a green environmental movement and concerns of sustainability. But normative notions of sustainability only attack these problems in incremental ways. Another suggested approach, geared towards real impact and breakthrough innovation, is to shift the frame of these growing issues of our time in a different way. Rather than plainly engineer better solutions and implement better technology, this paper describes design and design thinking education practice and student examples that seek to change the context dramatically, break the mold of current means of thinking about sustainability, and the difficulties student engineers face in doing so. In examining mechanical engineering students doing design work in the context of a graduate level mechanical engineering design course at Stanford University, this paper will highlight some difficulties students have in framing, conceptualizing and designing for the future.

Keywords: design thinking; engineering thinking; future thinking

Maintaining a high quality of life that encompasses work satisfaction and work-life balance is a critical long term need for the engineering practitioners. In this paper I argue that to grow professionally engineers need to design sustainable work environments for themselves through the productive use of information technology. I present a field study to identify 'open organizing' as a model to sustain engineering work. Open organizing refers to development of socio-technical infrastructure that allows people to successfully contribute to an endeavor irrespective of their physical location. Through a grounded theory analysis of field study data collected from an organization I call Digitech, I outline characteristics of open organizing practices and discuss their benefits for the engineers who worked there and for the organization. Overall, the findings reveal that successful creation and implementation of open organizing can result in better work-life balance for engineers and increase productivity and innovation.

Keywords: open organizing; sustainable work practices; engineering workforce; virtual work; socio-technical infrastructure; work-life balance

**Cesar Cardenas, Ricardo Sosa,
Raul Moysen and Victor Martinez**

287–292 Sustaining Sustainable Design Through Systemic Thinking

We believe that in order to ensure a sustainable future, the design of our built environment should be based on systemic thinking. A radical transformation is required in how we educate future designers. This paper proposes a systemic thinking framework that can be applied to assess the impact of innovative educational interventions. Results are presented from a study aimed at understanding the types of attitudes and skills that are necessary to reformulate unsustainable design practices. The authors identify a set of insights related to the evaluation of systemic thinking, its development, and its enactment in design practice.

Keywords: systems thinking; sustainable thinking; interdisciplinary teams; systemic focus

Benjamin Linder

293–296 Achieving a Sustainable Environmental Perspective

The design profession is in a position to address the environmental challenges faced by society and progress is being made in this direction. However, this paper cautions that achieving a sustainable environmental perspective within design requires educators and practitioners to go beyond the specifics of materials, tools and common strategies and address the very status of the environmental perspective. They will have to elevate this perspective above others and shift it from a relative requirement to an absolute one. Doing so will require several fundamental changes to design education and practice.

Keywords: environmental perspective; design practice; design education; sustainable design; green engineering; design for environment; design requirements

**John Oliver, Roland Geyer, Alan Savage,
Frederic T. Chong, Rajeevan Amirtharajah
and Venkatesh Akella**

297–304 Experiences with Life-cycle Aware Computer Architecture

The dark side of Moore's Law is our society's insatiable need to constantly upgrade our computing devices. As a result, the typical processor is only used for a fraction of its expected lifetime, despite the immense cost to produce a processor. While the rapid advance of technology makes silicon obsolete in a few years, we propose that chips should be reused for less demanding computing tasks. This re-use strategy creates a food chain of computing devices which amortizes the energy required to build processors over several computing generations.

This paper is structured into two parts. First, we describe a proposed a processor re-use strategy, showing that processor re-use makes sense for low-power, embedded processors. These re-usable processors occupy a design space that requires us to implement flexible and reliable processors. The second part of this paper describes student efforts centered around re-usable processors at California Polytechnic State University, San Luis Obispo as well as the University of California, Santa Barbara.

Keywords: computer architecture; life-cycle analysis; sustainability, education

**Deborah Kilgore, Andrew Jocuns,
Ken Yasuhara and Cynthia J. Atman**

305–313 From Beginning to End: How Engineering Students Think and Talk About Sustainability Across the Life Cycle

In this mixed-methods longitudinal study, 64 engineering students participated in a 15-minute lab-based engineering design task toward the end of their second and fourth years. Fifteen of those students also participated in open-ended interviews in their senior year, in which they were asked about their college experiences and conceptions of sustainable development. Analysis of these data reveal that while the students often talked about sustainable development in terms of limited resources and the life cycle of engineered products, relatively few considered the life cycle when actually engaged in engineering design. An in-depth examination of four students' educational experiences, narratives about sustainable development, and performance on the engineering task suggested implications for engineering education. Making sustainable development explicit in engineering classrooms and facilitating the development of self-directed learning skills in engineering students should improve students' abilities to develop knowledge about sustainable development and transfer such knowledge to new engineering contexts.

Keywords: design; sustainability; life cycle analysis; mixed methods research; undergraduates

**Elizabeth Gerber, Ann McKenna,
Penny Hirsch and Charles Yarnoff**

314–323 Learning to Waste and Wasting to Learn? How to Use Cradle to Cradle Principles to Improve the Teaching of Design

Engineers of the future are expected to be knowledgeable about the principles and practices needed to develop eco-effective products and manufacturing processes, yet it is challenging to integrate these principles and practices into undergraduate engineering design education. Our research explored one approach for beginning this process to help first-year students understand and apply cradle to cradle design practices in a user-centered, project-based design course. We used McDonough and Braungart's 5-step model of cradle to cradle design as a framework to guide students through several exercises and reflections related to the prototyping activity in the course. The results of the research showed that through limited exposure to cradle to cradle design, students made some progress toward developing adaptive expertise in this area, although they had difficulty reconciling their new-found interest in cradle to cradle design principles with the competing demands of client wishes, time constraints, and limited access to and knowledge of materials.

Keywords: design education; cradle to cradle design; sustainable design; reflection

**Robin S. Adams, Natalie Beltz,
Llewellyn Mann and Denise Wilson**

324–338 Exploring Student Differences in Formulating Cross-Disciplinary Sustainability Problems

Every day engineers are confronted with complex grand challenges. Grand challenges related to natural disasters represent a class of complex problems that require working across multiple disciplines and involve not just solving the immediate problem but designing long-term sustainable systems. In this paper, we present exploratory work to characterize students' ability to formulate cross-disciplinary problems for a complex, contextualized, and cross-disciplinary disaster relief scenario. This includes a description of the study implemented in three global contexts, data collection, analysis, and results including a discussion of the utility of the scenario tool to distinguish group differences. The paper concludes with implications for research, instruction, and assessment.

Keywords: design; cross-disciplinarity; sustainability; problem formulation

The overall purpose of this research was to research attitudes and threshold concepts (key concepts or gate keeper concepts) of beginning engineering students towards the relationship between environment/ecology and engineering specifically towards choosing: either (a) engineering as a career to make an environmental impact or (b) choosing environmental and ecological engineering as a specific engineering profession. The project was situated in the context of life cycle analysis and the environmental impacts of design, manufacturing, use and disposal of products. The study employed also an innovative research design: The researchers investigated students' conceptions and attitudes (and change of both) by asking students to co-design an educational game with them—through a series of workshops. Of particular focus was the change of students' conceptual understanding of core environmental and ecological concepts during the design process. First, we reported the results of a survey of 1437 first-year engineering students at the Purdue University, West Lafayette campus. The survey tested student knowledge of environmental issues, their prioritization of sustainable development in various contexts, and also explored student attitude toward change. We observed positive correlations between the high school science courses or high school environmental education, and the average environmental knowledge scores. There was no difference in average knowledge scores when comparing male and female students. In addition, we reported the results of an analysis of students' data as collected within the workshops. Second, we reported on preliminary findings on the participatory design workshops (n=24). The study revealed several areas of 'troublesome' knowledge of students.

Keywords: sustainability; environmental engineering; resistance to change; first-year students

This paper reports on the major undertaking of providing real problems with actual community partners as the basis of design projects for approximately 900 first-year engineering students. The initiative was dubbed the ROXIE project, 'Real Outreach eXperiences In Engineering'. The goal was to have engineering students work on real projects with actual clients rather than contrived less meaningful projects. Sustainability is a key element in three primary aspects of the ROXIE project. First, numerous projects for the community were directed at finding sustainable solutions to problems around their operation or economic viability. The second sustainability aspect for the ROXIE project involves identifying hands-on activities and associated materials for the once per week workshop sessions associated with the large lecture course. The third aspect of sustainability for the ROXIE project addresses issues of how to sustain and maintain the partnerships and instructional infrastructure of such a large undertaking for the long-term. This paper provides the motivation and greater detail of the background of ROXIE and then expands upon the three aspects of sustaining sustainable design highlighted above. Early results of integrating an area of social significance into design education have been very positive. Reflections from students, community partners and the instructional team are shared. Summary and future plans are also included.

Keywords: design education; first year design; service learning; student engagement; sustainable design; large engineering class

Environmental sustainability and eco-friendly design are becoming increasingly important in engineering today. This paper discusses green design in the KAIST Freshman Design Program. It is shown that students and faculty members tend to choose green design projects, even when not required. Students have successfully adapted general design processes and formal design theories to eco-friendly design projects by defining eco-friendly functional requirements, constraints, and selection criteria. The use of a more formal stakeholder analysis to address a wider range of environmental sustainability issues has promise. However, these benefits have not yet been reflected in freshman projects. Ultimately, ED100 may be a good model for incorporating green design in a general design course.

Keywords: green design; design education; design theory; first year

In the fall of 2007, Purdue University began integrating sustainable design topics into our Introduction to Engineering Problem Solving and Computer Tools course which our first-year engineering students complete prior to advancing to their specific engineering disciplinary programs. In the Spring of 2008 we began assigning a six-week design project related to Sustainable Design. The students work in teams of three-to-four students to consider their living spaces and how they might make those spaces more sustainable. In this paper, we present an overview of the educational activities, including the material that is presented to students and more details on the design project. Additionally, we present an analysis of some of the students' final projects. We present three cases which represent different student responses. This work will contribute to what we as a design education community understand about first-year engineering students' ability to engage with this material.

Keywords: sustainability; design; first-year engineering; students; design projects; normalized sustainability

Engineers have a primary responsibility to help society develop sustainably. Engineering education has an obligation to integrate sustainable design principles into the curriculum of all engineers. This paper describes the integration of sustainable design principles into a second year engineering design course taken by all engineering students at the University of Guelph. The approach requires students to develop and measure their design-build-test project from three specific measures to reflect economic, societal and environmental dimensions of their system. Many students are able to understand the challenges associated with succeeding by all three measures within the same design. These students see the importance of creativity and innovation in overcoming the apparent conflicts. However, it is also evident that the efforts to date are not sufficient to deeply embed sustainable design thinking in all of the students.

Keywords: sustainable development; design; second year

Many senior engineering capstone projects focus on an open-ended design experience, often ignoring the concept of design sustainability. In contrast, the work reported on in this paper describes a multi-disciplinary engineering team that was given the opportunity to research detailed design factors that contribute to sustainable designs. This paper focuses on the reverse engineering and comparison of design sustainability of four consumer inkjet printers using given design metrics that influence sustainability. Some metrics were open to modification, using these case studies and prior research as an empirical benchmark. The capstone team established a teardown and assessment procedure to standardize the reverse engineering process, the apparent antithesis of their pre-conceived notions for the course (students generally think 'to design' is 'to construct'). In a clear effort to convey the current opportunities in designing for sustainability, the students were able to draw insight from the design comparison of a discontinued printer model (manufactured in 2001) with those currently on the market. While one would intuitively expect the older model to rank lower on a sustainability scale, students also theorized opportunities pertaining to both form and functional improvements in sustainability for all printers involved. Using specific design attributes that have proven implications on design complexity, and therefore design [1], the capstone team has developed a database tool to classify and score consumer products.

Keywords: capstone design; sustainability metrics; product architecture; reverse engineering

A pilot implementation of an experimental interdisciplinary course on climate solutions was undertaken at San José State University in the fall semester of 2008. The course, co-taught by seven faculty members from six colleges, was approved for a general education requirement and was open to upperclass students campus-wide. A course with such a breadth of topics and range of student backgrounds was the first of its kind here. The lessons learned from the pilot effort were assessed from student, faculty, and administrative perspectives. The educational benefits to students from the interdisciplinary format were found to be substantial, in addition to faculty development. However, challenges associated with team-teaching were also encountered and must be overcome for the long-term viability of the course. The experimental course was approved as a permanent course starting in the fall semester of 2009 based on the pilot effort, and plays a role in the College of Engineering's recent initiatives in sustainability in addition to campus-wide general education.

Keywords: team-taught course; project-based learning; multidisciplinary instruction; interdisciplinary instruction

Steve Lambert

401-407 Sustainable Design Throughout the Curriculum Using Case Studies

Case studies are presented as an option to integrate various thematic concepts such as sustainable design throughout a conventional engineering curriculum. This approach is best with the pervasive and consistent use of cases, which in turn requires a sustainable supply of good quality design cases covering a wide range of engineering topics. A new program at the University of Waterloo is described which is focused on the development and implementation of case studies. A key innovation of this program is that cases are developed primarily from student work term experience, through conversion of work term reports. Waterloo engineering students currently produce approximately 4000 of these work term reports every year, making them a rich source of design case material. The Waterloo Cases in Design Engineering program is presented and discussed, along with early results in the development and implementation of cases.

Keywords: case studies; sustainable, design; co-op education; student experience; case writing

Christopher B. Williams, Lisa D. McNair,
Erin D. Crede, Marie C. Paretti and
Janis P. Terpenny

408-417

Designing Hands-On Teaming Activities: Exploring Sustainability Tradeoffs for Courses with Large Enrollments

In this paper, the authors explore sustainability issues that exist in the development of hands-on activities for classes with large enrollments. Specifically, the authors study four different team-building activities, all with varying levels of resource commitment, to assess potential tradeoffs between cost, environmental impact, and learning objectives pertaining to design and teaming. Faced with several alternatives and multiple, conflicting objectives, the authors approach this choice from a design context. Specifically, following the identification of activity constraints and objectives, activity alternatives are evaluated against several metrics with post-activity student surveys. Survey data is then translated into an appropriate input for a systematic selection framework, the selection Decision Support Problem. The use of this framework allows the authors to select a teaming activity alternative that offers the best compromise to their multiple design goals.

Keywords: engineering design education; design teaming; first-year design; designing design experiences

Derrick Tate, Timothy Maxwell,
Atila Ertas, Hong-Chao Zhang,
Urs Peter Flueckiger, William Lawson,
A. Dean Fontenot and John Chandler

418-429

Transdisciplinary Approaches for Teaching and Assessing Sustainable Design

Sustainable design can be defined as incorporating larger environmental, resource, and social issues into decisions of the conceptualization, design, manufacture, operation, and end-of-life of products and systems. These larger issues include, for example, environmental concerns, energy independence, economic viability, and social impact. This paper argues for the need for transdisciplinary approaches for teaching and assessing sustainable design for undergraduate engineering curricula. These transdisciplinary approaches are discussed in the context of application to traditional senior- and freshman-level ('capstone' and 'cornerstone') design projects and incorporation into innovative technology programs that provide outreach and seamless pathways for recruiting engineering students and developing a sustainable workforce.

The teaching and assessment of sustainable design concepts and approaches should be driven by social and industrial needs while addressing forward-looking issues including the design and development of innovative products and service systems that use dramatically less energy, the reduction of energy intensity in manufacturing, and the provision of energy using 'green' technologies. The sections of this paper cover transdisciplinary design; sustainable design projects for undergraduate education; and pathways for a sustainable engineering and technology workforce.

Keywords: sustainable design; transdisciplinary design; undergraduate education; seamless technology program

Martin H. Bremer, Eduardo Gonzalez
and Emilio Mercado

430-437

Teaching Creativity and Innovation Using Sustainability as Driving Force

Undergraduate and graduate students are often exposed to definitions and lectures about creativity and innovation to accomplish some internal or external requirements about the syllabus and curricula, but they have little opportunity to do and experiment the creative processes and create innovative products and services.

The teaching philosophy at Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) is focused in active a learning methodology which gives students an opportunity to learn by doing hands-on-projects with different goals. This opportunity has been used to do projects that face real problems but defining the problems using sustainability issues as part of the problem definition and to address solutions that are better than using just economical or technical goals.

There are many of challenges and even more possible forms of failure while trying to implement active learning in an creative and innovative way in the framework of sustainability, because it depends in the student, the problem setting, the availability of needed resources and that the teacher states the problem properly, has the flexibility to handle unexpected situations as well as results that are either negative or not the original ones, but that should not affect the grades of the student if he accomplished the learning goals.

Keywords: creativity; innovation; active learning; sustainable solutions

Linda Vanasupa, Roger Burton,
Jonathan Stolk, Julie B. Zimmerman,
Larry J. Leifer and Paul T. Anastas

438-450

The Systemic Correlation Between Mental Models and Sustainable Design: Implications for Engineering Educators

Many studies have illuminated our understanding of the kinds of competencies and behaviors exhibited by effective designers. Against the backdrop of global challenges made more urgent by unintentional negative impacts of engineered products and systems, however, we are left to deduce that our ways of educating engineering designers is fundamentally flawed. We assert that one can trace the cause of our collective, unintended negative consequences to the mental models of reality that we consciously or unconsciously carry. In this paper, we present the case for developing awareness and facility with mental models. We also suggest an alternate mental model as the foundation for sustainable design. This model depicts reality as embedded systems of economies inside society and inside the environment. We also discuss how the engineering educator can use the model to build a foundation for holistically viewing design for sustainability. Student responses to a course based on the proposed ideas are also presented as evidence that students' can value mental models and that working with them effectively changes their world conception.

Keywords: systems thinking; sustainability; sustainable design; mental models; design

Tomorrow's sustainable designers will need an arsenal of tools for innovation. An approach for teaching design methods and innovation is described. A new approach for teaching design methods based on the use of analogous products to provide concrete experiences prior to the method's application to a novel design problem was evaluated. Students' opinions of the various design methods and their perceptions of the class's influence on their creativity were also measured. Past experiments have shown that the presentation of example solutions has the potential to cause design fixation thus limiting the design solutions considered. Due to this, the teams' final proof-of-concept models were compared with their initial analogous products to measure degree of design fixation. Results show that the use of analogous products early in the class's design process does not appear to cause design fixation but the students would prefer to have standardized products to learn the methods with. The design methods taught in class may assist in overcoming the design fixation introduced by the analogous products or it may be that since the analogous products were cross-domain analogies they may have induced less design fixation. The course which included sustainable design projects was highly successful in influencing students' creativity. Students' clearly felt they were better at generating ideas and that the course had improved their innovation skills.

Keywords: design creativity; innovation; analogy; design fixation

Marie C. Paretti, David M. Richter and Lisa D. McNair 462–469 Sustaining Interdisciplinary Projects in Green Engineering: Teaching to Support Distributed Work

Design projects associated with sustainability efforts often require interdisciplinary student teams to address technical, social, and environmental concerns. While educators are increasingly seeking to understand and actively teach interdisciplinary collaboration skills, less attention has been given to the structure and context of such teams. In this paper, we draw on prior research to analyze interdisciplinary teams as sites of distributed work. Using frameworks that identify key characteristics of co-located and distributed work, we identify key factors in interdisciplinary design teams that may inhibit collaboration. We conclude with strategies for faculty to help sustain such teams through concrete course management practices and through explicit learning outcomes that can help students transfer teaming skills learned in this environment to new projects.

Keywords: design education; distributed work; interdisciplinary teams

Philip E. Doepker 470–478 Sustaining Sustainable Engineering Design Projects

Experiential learning has been emphasized in the School of Engineering at the University of Dayton for over 25 years. The evolution has gone from individual projects to team projects and from single discipline to multidisciplinary teams. In the last 5 years the percentage of projects related to design for the environment, design of thermal systems and renewable energy systems reached about one-third of the capstone design projects. The purpose of this paper is to share the experiences over these last 5 years. Thus, this submission covers the applied aspects of sustainability in design education. In doing so this paper concentrates on three areas. First, there must be a venue, or a sustainable design landscape, in which sustainable design and development projects can be implemented. Second, it is important that the appropriate resources be available in order to facilitate sustainable design. Finally, there will be a review of the types and scope of these projects and the lessons learned over this time.

Keywords: sustainable design; product realization process; renewable and clean energy; innovation; entrepreneurship

Corinna Fleischmann, Sarah Thompson, Luke Zitzman, Luis Garcia and Nicole Gurr 479–488 Sustainability: A Campus Initiative

The United States Coast Guard Academy is in the process of developing a policy that will encourage and, in some cases, even mandate the implementation of sustainable practices and design for the campus. Buy in from Facilities Engineering and the school Superintendent indicates the policies and procedures developed will dictate property management, facilities operation, and future construction. To execute this initiative, a civil engineering student senior design team was formed to provide a campus starting point, research and create guidelines for the formation of a sustainability policy, and submit a design that would improve the Academy's environmental stewardship. This paper describes the background, motivation, process and ultimate outcomes realized due to the creative and dedicated efforts of the senior design team.

Keywords: US Coast Guard; sustainability; clean air-cool planet

Lora Oehlberg, Ryan Shelby and Alice Agogino 489–498 Sustainable Product Design: Designing for Diversity in Engineering Education

Current and future engineers will need to address sustainability's triple bottom line, simultaneously addressing financial, environmental, and social goals. There is also a need to improve diversity in engineering, both in the communities served by new technology and the representation of gender and ethnic minorities among engineering professionals. We present data gathered from 'Engineering 10: Introduction to Engineering Design and Analysis'. This freshman course includes a six-week Mechanical Engineering module entitled 'Sustainable Human-Centered Design', that covers both human-centered design techniques as well as the principles of sustainable design. We investigate these students' experiences, confidence, and goals, focusing on aspects that might vary with gender and ethnic affiliation. We suggest that enrollment diversity in engineering could be improved by teaching engineering in a manner that both complements the previous engineering and design background of all students, as well as emphasizes the learning goals most important to underrepresented engineering students. We also recommend offering sustainability and service learning projects that appeal to women and ethnic minority students in order to pique their interest and encourage their pursuit of an engineering career.

Keywords: community-based design; project learning; freshman design; diversity in engineering; sustainable design

John W. Wesner and Clive L. Dym 499–504 What We Have Learned at Mudd Design Workshop VII: 'Sustaining Sustainable Design'

This paper summarizes and highlights the presentations and discussions that took place during a workshop on sustainable engineering design in both practice and education. Supported by Harvey Mudd College's Center for Design Education, Mudd Design Workshop VI, 'Sustaining Sustainable Design,' was held at Mudd during 29–31 May 2009. This paper describes both the key ideas that emerged from the presentations and discussions of the participating engineering design educators, practitioners and researchers, and the methodology used to capture and retain those ideas.

Keywords: design education; sustainable design; sustainability