Sustainability and Education: The Need for New Degree Options

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Abstract:
The need to possess knowledge, skills, and perspectives in sustainability has never been greater for sustainability has gained recognition and importance in businesses, industries, non-profits, government agencies, higher education, and in the general public’s consciousness. The goal of meeting today’s needs without harming future generations’ ability to realize their potential is the hallmark of sustainable practices, and there is widespread interest from many engineering disciplines and sectors in developing, enhancing, and integrating sustainability into aspects of products, services, and solutions. Sustainability can be taught in many engineering and technology disciplines, including, but not limited to: civil, aeronautical, electrical, mechanical, biomedical, manufacturing and architecture. This paper will look at integrating sustainability into existing curriculum as well as the possibility and attributes of new degree programs designed to address the new green economy. In addition, this paper will look at how sustainable knowledge affects a graduate’s ability to establish a green career and how the future green global workforce will address stakeholders’ needs and expectations of a greener and cleaner environment. Most importantly, this paper will look at the calls for changes in engineering education to prepare engineering students for global challenges with respect to climate change, sustainability, and other grand challenges that the world is facing.

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- Sustainable development
- Structural dynamics
- Engineering education
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ABSTRACT

The need to possess knowledge, skills, and perspectives in sustainability has never been greater for sustainability has gained recognition and importance in businesses, industries, non-profits, government agencies, higher education, and in the general public’s consciousness. The goal of meeting today’s needs without harming future generations’ ability to realize their potential is the hallmark of sustainable practices, and there is widespread interest from many engineering disciplines and sectors in developing, enhancing, and integrating sustainability into aspects of products, services, and solutions.

Sustainability can be taught in many engineering and technology disciplines, including, but not limited to: civil, aeronautical, electrical, mechanical, biomedical, manufacturing and architecture. This paper will look at integrating sustainability into existing curriculum as well as the possibility and attributes of new degree programs designed to address the new green economy. In addition, this paper will look at how sustainable knowledge affects a graduate’s ability to establish a green career and how the future green global workforce will address stakeholders’ needs and expectations of a greener and cleaner environment. Most importantly, this paper will look at the calls for changes in engineering education to prepare engineering students for global challenges with respect to climate change, sustainability, and other grand challenges that the world is facing.
WHY TEACH SUSTAINABILITY?

Sustainable development is a contemporary issue for everyone to embrace, especially engineers, engineering technologists, architects, designers, manufacturers, etc., and especially engineering and engineering technology educators. Sustainability and sustainable development is common practice in the European Union and many other developed countries; however, the concept is not widely practiced or common in the United States (U.S.) let alone often not taught in engineering education within the U.S.

However, several engineering societies and professional organizations within the U.S. have made declarative statements about their commitments to sustainable development. As early as 1996, the American Society of Civil Engineers changed their code of ethics to include a definition of sustainability (ASCE). In 1999, the American Society for Engineering Education (ASEE) Board of Directors approved the following statement, “ASEE believes that engineering graduates must be prepared by their education to use sustainable engineering techniques in the practice of their profession and to take leadership roles in facilitating sustainable development in their communities” (ASEE, 1999). In 2002, the American Association of Engineering Societies; American Institute of Chemical Engineering, American Society for Mechanical Engineers- International–Environmental Engineering Division, National Academy of Engineering, and the National Society of Professional Engineers made a declaration to the World Summit on Sustainable Development held in Johannesburg, South Africa, to commit to creating a sustainable world (IEEE, 2002). The National Academy of Engineering addresses sustainable development issues by supporting research and publishing reports on sustainability including: Sustainable Federal Facilities: A Guide to Integrating Value Engineering; Life Cycle Costing, and Sustainable Development; Harnessing Ingenuity for Sustainable Outcomes, Technology and Sustainable Development; and Sustainable Development and Systems Engineering. The American Society of Civil Engineers (ASCE), the American Society for Engineering Education, and the American Institute of Chemical Engineers (AIChE) joined together to co-sponsor a forum on Sustainability whose mission is to help promote the principles and practice of sustainability (Engineers Forum on Sustainability). While all of this is a good beginning, it falls short of having sustainability embedded in engineering education.

It is enlightening to review engineering students and administrators comments on this topic. The students who won the Daimler United Nations Educational, Scientific, Cultural Organization (UNESCO) Mondialogo Engineering Award for 2008-09, for example, made the following statement about engineering education (Mondialogo, 2009, p.1): “First, we believe that there need to be changes in engineering education, to all engineers for sustainable design and implementation practices. This means to be more interdisciplinary, both within and beyond engineering, and more opportunities to frame solutions to real world problems.” They went on the state: “Opportunities
abound for young engineers to new and age-old challenges solving problems and
developing businesses (“techno-preneurship”) on a base of sustainability, to promote
a green economy” (Mondialogo, 2009, p.1). In addition, the former dean of Texas Tech, Dr. Pamela A. Elbeck, now President of the University of the Pacific, noted:
“The dilemma our profession has faced is that, in an effort to prepare a 22-year-old
with the depth of knowledge and skills needed by a specialized engineering
professional, our undergraduate curriculums are effectively six years’ worth of
engineering study crammed into four years. The resulting rigid, unrelenting
curriculum doesn’t allow our engineers to develop sufficient capabilities in other
critical areas such as understanding the global, economic, environmental or societal
context of engineering or developing strong communication, interpersonal and
leadership skills. It is time that our profession adopts best practices seen elsewhere,
such as in the health professions, and relies on a professional master's or even a
professional doctorate as the primary entry degree “(Elbeck, 2009, p.1).

CASE STUDY: GERMANY

Germany is an excellent example of a country that practices sustainability. For
more than thirty years, industry and business have had numerous laws and regulations
concerning environmental issues and practices. Sustainability is even part of the
German culture. The subject of sustainability is taken very seriously by the European
Union (EU), it is the government and industry’s response to climate change,
dwindling natural resources, and social responsibility (EU). According to Paul
Hawkins, the author of the *Ecology of Commerce A Declaration of Sustainability*, the
single most important damaging aspect to destroying the earth, currently and in the
past, is the failure of a company to include the cost of replacing the product or
process it takes from the earth (Hawkins, 1993). In the EU and Germany these kinds
of costs are routinely taken into account along with the costs to society. The “triple
bottom line” (people, planet, profit) has been the norm in German business for many
years. In 2000, a Forum for Sustainable Development of German Businesses was
started by 23 global companies to integrate “econsense” an effective framework to
strengthen the exchange of information on sustainable development and corporate
social responsibility, and raise the levels of competence in these important areas.
Sustainability focuses on balancing societal, environmental and economic
stewardship when making business/financial decisions (Econsense, 2009). A
different mindset is involved in thinking about the larger picture where the
environment and the society are equally important as the financial gain. There is a
sense of responsibility for future generations, for preserving the land, natural
resources, a respect for using only what is necessary and respect for the environment,
and people.

German business and industry sustainable practices are excellent to emulate
because of their long history in this area. Lessons can be learned and years of
practices and outcomes can be evaluated to show that the years of sustainable
development have resulted in years of innovation.
INTEGRATING SUSTAINABLE CONCEPTS IN COURSES

It is easy to imbed sustainable modules into existing engineering courses. Some examples of these modules or topics are listed in Table 1.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Examples of sustainable modules imbedded in courses</th>
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<tbody>
<tr>
<td>Architecture, Design, Civil, Construction</td>
<td>Green design, green roofs and other construction-related sustainable design, building design and computer aided energy simulation</td>
</tr>
<tr>
<td>Electrical Engineering and Electrical Engineering Technology</td>
<td>Renewable energy, wind turbine technology, solar energy technology, and energy conservation practices in commercial, industrial, and residential environments</td>
</tr>
<tr>
<td>Architecture, Design, or Manufacturing</td>
<td>Bio-mimicry related to sustainable design and product development and design using recycled material</td>
</tr>
<tr>
<td>Mechanical Engineering and Mechanical Engineering Technology and Manufacturing</td>
<td>Sustainable development in manufacturing processes (e.g., new automotive painting methods, healthy indoor air quality for workers, cradle-to-cradle concepts for materials resource maximization)</td>
</tr>
<tr>
<td>Technology</td>
<td>Analysis of new innovative technologies that support sustainable practices in specific industries and organizations</td>
</tr>
<tr>
<td>Management, Operations, Leadership, Ethics</td>
<td>Change management practices in creating, implementing, and nurturing a culture of sustainable practices; green to gold concepts</td>
</tr>
<tr>
<td>Public Policy</td>
<td>Building design codes, energy consumption, and recycling issues; new laws and regulations - European Union regulations and LEED standards</td>
</tr>
</tbody>
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The easy part is to identify a discipline and integrate concepts and applications of sustainability into an existing course. Yet many faculty are likely not aware of what sustainability is about or how it relates to their discipline. The difficult part is to capture the attention of faculty members and to make them aware of sustainability concepts and practices in their area and why it is important for solving problems today and in the future. The students, for the most part, understand why it is important for solving the challenges of the world.

A great example of how this can be handled on a campus level happened at Missouri State University at Springfield. During the 2008-09 academic year, the public affairs theme for the campus was sustainability. During that time the campus
celebrated the sustainability theme in various ways. The theme year events and discussions concluded with a three day conference with experts on sustainability, environment, and economics. The invited experts from around the U.S. and the world discussed sustainability in an open forum. The campus hosted a series of workshops that dealt with incorporating sustainability into the curriculum. Faculty who already incorporate sustainability in their courses worked with faculty who were new to the topic and were looking for ways to incorporate sustainability into their own courses. At Missouri State, sustainability was developed as a cornerstone principle for a course that all freshman are now required to take. This is an excellent example of how a campus can bring sustainable practices into the classroom on a large scale (MacGillis and McDonald, 2009).

Another difficult area, according to Kevin Coyle, the Vice President Education and Training for the National Wildlife Federation, is the nature of higher education, which is sharply divided by disciplines that tend toward “broad system oriented thinking” about societal and environmental problems and therefore don’t see the relationship. He suggested, “You almost need an ombudsman to say, are you paying attention to this because that is related to this over here” (MacGillis and McDonald, 2009). In other words, sustainability interconnects many disciplines, as is noted above. It is a great way to collaborate with colleagues in other disciplines and it breeds innovation (the German’s are well aware of this phenomenon.) Many sustainable development projects have given birth to new products and businesses. It is on the boundaries of disciplines that the truly innovative solutions to our planet’s ills will be founded.

There are also opportunities for engineering faculty to attend National Science Foundation (NSF) sponsored summer workshops to learn how to incorporate sustainable modules into their current courses or to develop an entire sustainable course. These workshops help faculty to improve their courses, obtain funding for educational innovations, and become part of a growing network of educators in Sustainable Engineering. For the past two summers, these workshops have been offered by the Center for Sustainability, which is run by faculty from Carnegie Mellon University, the University of Texas at Austin, and Arizona State University.

SUSTAINABLE DEGREE PROGRAMS: EXAMPLES

With the rising cost of energy and issues of global warming, businesses have joined students in demanding that schools pay closer attention to issues of sustainable development. Many business schools have MBA programs specifically dedicated to sustainability or concentrations in this area. Albert H. Segars, Director of North Carolina’s Center for Sustainable Enterprise says, “More students are entering business with an eye toward making the world a better place” (Killebrew, 2008).

The same is happening in engineering and technology. The Dean of the College of Architecture at the University of Arizona said that more students today are spending their “green” on a greener education. His faculty are collaborating with the
School of Natural Resources to offer environmental courses, a trend which seems to be holding true nationally. “There is a sense of urgency that’s never been there before,” Cervelli said, “and young people are looking to the future with a sense of purpose. I haven’t seen anything like it since the original Earth Day in the 1970’s, regarding the overall environmental movement.” The School of Management at Arizona University is also building sustainability into their program. They will teach corporate social responsibility, energy, and environment. The School of Engineering has multiple degrees related to sustainability; Biosystems Engineering, Hydrology, and Chemical Engineering (Killebrew, 2008, n.p.).

Faced with a growing demand for graduates knowledgeable in sustainability, the Oregon Institute of Technology is adding sustainable courses to its current Bachelor of Science Environment Degree. Students will be taking courses in the built environment, renewable energy, and fuel cell technology to mention just a few, which will be taught by engineering and engineering technology faculty. The Director of the Environmental degree program said, "OIT graduates in this program will not only be able to identify key elements of complex programs, they will have exposure to new sustainable technologies to help solve them" (Haight, 2009, n.p.).

In addition to offering separate courses in sustainability to students, the University of Arizona offers two stand alone degrees in sustainability. One is a Bachelor of Arts in Sustainability. Students pursuing this degree choose to follow one of four tracks; society and sustainability; policy and governance in sustainable systems; international development and sustainability; and sustainable urban dynamics. The other sustainable degree is a Bachelor of Science in Sustainability. Students pursuing the BS degree must choose from three tracks: sustainable energy, materials and technology; economics of sustainability; and sustainable ecosystems. Both of these degrees are housed in their new School of Sustainability.

Other universities that currently offer sustainable degrees are St Petersburg College which offers a BS in Sustainable Management and Appalachian State University which offers four sustainable degrees; BA in Sustainable Development; BS in Sustainable Development in Agroecology and Sustainable Agriculture; BS in Sustainable Development in Community, Regional and Global Development; and BS in Sustainable Development in Environmental Studies.

In addition to some universities teaching sustainability within their current courses, a few universities have taken steps to propose and approve new degree programs in sustainability. It should also be noted that there are unique and innovative features that accompany proposed new degree programs in sustainability. Some of these features include:

1. They are multidisciplinary. They cut across the disciplines of science, engineering and leadership for example, to provide a comprehensive approach to education in sustainability.
2. They are interdisciplinary and transdisciplinary. They mix course content from traditional disciplines into individual courses, allowing students to see
the relationships between concepts and theories in one discipline in the context of others (e.g., sustainable lifestyles, engineering economy) and they run across traditional subject boundaries such as arts and science.

3. They can be undergraduate programs. This will build the foundation for future graduate programs and will provide an entry point for those interested in sustainability, yet who may lack the advanced education to apply to a more advanced level degree.

4. They can encompass practical application courses so that students are not solely exposed to theory but will be engaged in hands on experience with sustainable technologies.

5. They can be globally focused. The curriculum can provide international experiences as well as discussion of international topics that will encourage a focus upon the world outside of a particular State and the United States.

6. They can involve community and service related projects into the curriculum so that students have an opportunity to see the impact of green technologies within real life situations.

7. They can provide the opportunity to learn about emergent technologies that will place the graduates at the forefront of cutting edge ideas and concepts in an era struggling to come to terms with the impact of technology.

8. They can develop graduates with entrepreneurial skills that are needed to advance in a competitive job market.

A SUSTAINABLE REPORT CARD

The National Wildlife Federation (NWF), Princeton Survey Research Associates International, and NWF Campus Ecology with numerous other co-sponsors support a comprehensive national campus survey called, “Campus Environment 2008: A National Report Card on Sustainability in Higher Education.” The 2008 survey was the second in a series on nationwide surveys that was designed to track trends and advances in environmental stewardship, sustainability activities and related curricular offerings in higher education. The first survey was reported in 2001. All 50 states participated in the 2008 survey as well as 1,068 institutions, which is 27% of US colleges and universities (McIntosh, Gaalswyk, Keniry, and Eagan, 2008).

In the Forward, Kevin Coyle, (referenced above), indicted that comparisons of the 2001 data to 2008 data showed positive changes occurring in the greening of campuses, however, it also showed that between the years 2001 and 2008 the amount of sustainable related education offered on campus declined. Coyle goes on to conclude that the students of today will lead our businesses, educational institutions and government agencies. These students need a type of education that will prepare them for a world of new and cleaner forms of energy production, transportation, agriculture, natural resources management, health care, new technologies, etc. Kevin said, “To achieve this at the speed required will call for serious new support including new guidance and funding from federal and state governments, and a complete rethinking of how we educate every degree candidate from architecture and
engineering to accounting and even teaching itself” (McIntosh, Gaalswyk, Keniry, and Eagan, 2008, n.p.).

The report indicated that from 2001 to 2008, the number of programs to support faculty professional development on environmental or sustainable topics had decreased. In 2001, 8% of students took a course related to the environment or sustainable topic and in 2008 the percentage dropped to 4%. The good news from the report was that there was a commitment from university leaders to do more (setting and reviewing sustainable goals, staffing sustainable programs, and orienting students, staff, faculty) in the sustainable area. The other bright note in the survey indicated that campus leaders were much more likely to rank environmental and sustainability programs among their highest priorities and that competing priorities are no longer the obstacles that they were in 2001.

SUSTAINABLE GREEN CAREERS

Students who at least have some knowledge of sustainability related to their discipline can be winners in obtaining careers in the new green jobs market. Using the University of Arizona as an example, students who learn biosystems engineering apply engineering skills to plants and animals; manage wastewater and ecosystems; and understand water issues (i.e., erosion, fire sensitivity to drought). These graduates work at consulting firms or for the state or federal agencies (EPA). Students who learn hydrology and apply chemistry, physics, and calculus to study surface and ground water, water systems, reactions and hydrometeorology graduate working at state or federal agencies, consulting groups, and nature conservancies. Students who learn business administration and the impact of energy and the environment work at business or environmental consulting agencies and government agencies. Architecture and landscape students learn to build energy efficiency and water conservation into design and materials. These graduates work at sustainable private or public architectural firms. Students who earn a degree in chemical engineering and learn about water treatment, air pollution, hazardous waste treatment, biodegradation of hazardous materials, and create environmental impact statements. These graduates work for NASA, various industries, and municipal, state, and federal government agencies. These are just a few examples of what kind of current degrees supplemented with sustainable courses, would allow graduates enough sustainable knowledge to gain positions in a “green or sustainable job’ upon graduation (Killebrew, 2008).

Supplement to this is the Pew Charitable Trust Report: The Clean Energy Economy: Repowering Jobs, Businesses and Investments Across America (2009). This report sheds light upon solutions to the struggling U.S. economy and focuses its attention on the emergent clean energy sector. It notes (Urahn, S. and Reichert, J. (2009), p.4), based upon substantial research, that “jobs in the new clean energy economy grew at nearly two and a half times the rate of U.S. jobs overall between 1998 and 2007. These jobs included all kinds of workers—blue collar and white collar, technical and clerical—and more than 68,200 employers in all 50 states.”
These jobs will continue to surge as state and federal politicians develop new policies that focus upon sustainable development and the reduction of our dependence on foreign oil. In fact, some of the most impressive growth was in states where traditional industries have languished. The projected ten year job growth for Indiana, for example, is, for all jobs, -1.0%. However, the same period growth for clean energy economy jobs is close to 18%.

As traditional manufacturing jobs in the U.S. wane and disappear, and as energy prices soar, it must be realized that this country is locked into the realization that it is carbon-constrained and must seek out other alternatives to reduce demand for energy and to sustain current and future demands. The Pew report notes (p.5) that the clean energy economy cuts across five categories: “1. Clean Energy 2. Energy Efficiency 3. Environmentally Friendly Production 4. Conservation and Pollution Mitigation and 5. Training and Support”. It is within Training and Support that post secondary educators should take heed of the tremendous opportunities for creating new degree programs that address this new economy. This rises above adding new content or chapters to existing courses, but, instead, places a need on the development of an entirely new outlook to the curriculum and the manner in which courses are delivered.

It is also prudent to note that of the five categories noted above, the one that is currently in the lead, in terms of development, is the Conservation and Pollution Mitigation category and it contains the recycling industry. This is the easiest to understand, the easiest to mobilize and requires the least amount of infrastructure and technological expertise and training.

The other categories: Clean Energy, Energy Efficiency and Environmentally Friendly Production require specialized training that will place a large demand upon post-secondary institutes in this country. A large portion of this will fall onto engineering programs, yet only engineering programs that have the wisdom to incorporate other disciplines and new pedagogical approaches. Theory will be displaced by hands-on approaches as students and industry demand to move beyond recycling to determining how, for example, solar panels actually get installed, how green roofs are constructed. Those that ignore these wholesale types of curricular changes will likely be faced with declining enrolments and graduates that struggle to find employment in this exciting, new, clean energy economy.

As the Pew report concludes (p. 42):

Across the country, jobs and businesses in the clean energy economy are being driven by consumer demand, venture capital infusions by private-sector investors eager to capitalize on new market opportunities, and policy reforms by federal and state lawmakers who want to spur economic growth while sustaining the environment. Today, every state has a piece of the clean energy economy. But there will be winners and losers going forward.

FUTURE TRENDS TOWARDS GREEN JOBS

Another report on future Green Jobs was commissioned by the United Nations Environment Program in conjunction with the International Labour Organization, International Organization of Employers and International Trade Union
Confederation. This 352 page report is titled, *Green Jobs: Towards decent work in a sustainable, low-carbon world.* For purposes of this paper, green jobs are defined as those that contribute substantially to preserving or restoring environmental quality and in the areas agriculture, manufacturing, research and development, administrative, and service activities that contribute to preserving or restoring environmental quality. Green jobs would also include jobs that protect the ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or eliminate waste and pollution (Renner, Sweeney, and Kubit 2008).

The authors of the Green Jobs Report found that the global work force supports 300,000 workers in wind technology and approximately 170,000 in solar photovoltaic (PV). More than 600,000 workers are employed in solar thermal development and approximately 1.2 million are employed in developing biomass technology. Considering the increase of interest in alternative energy, the future may see worldwide employment soar as high as 2.1 million in wind technology and 6.3 million in solar PVs by 2030, and somewhere in the area of 12 million jobs in biofuel related agriculture and industry. Estimates indicate strong potential for large job creation in coming years. Installation and maintenance of solar PV and thermal systems in particular offer the most growth (Renner, Sweeney, and Kubit 2008).

The report also indicates that a leading barrier to renewable energy and energy efficiency growth in the U.S. is the shortage of skills and training as noted by the U.S. National Renewable Energy Laboratory. This was also the case in Germany and Britain. These shortages will continue to drive demand for educated workers in the new green economy, placing the burden of educating and producing skilled workers on the world’s universities. The level of education necessary to be proficient in green technology requires universities wishing to service their communities to expand existing degree programs or possibly create new ones. In order to provide employees for these green jobs, engineering and technology schools need to respond, as noted above, with new courses and programs that will fit industry’s need for this green change. All levels of engineering and technology education will be needed in this new green environment. Almost every industry imaginable will be touched by sustainability trend.

**CONCLUSION**

The theme for the World Engineering Convention, held in Brazil December 2008, was “Engineering Innovation with Social Responsibility.” Over 5,500 engineers from around the world attended the meeting. The Key Note Speaker, Dr. Hans J. Hoyer, representing the International Federation of Engineering Education Societies (IFEES) addressed the audience on “Global Competence and Mobility in Engineering Education.” His talk was about the challenges and obstacles faced by globalizing engineering preparation and examples of recent organizational developments to create socially responsible networks of engineering. Social responsibility includes the knowledge of sustainability (IFEES, 2009).
It is the responsibility of engineers and engineering faculty to remain current in their discipline, which includes the new knowledge of sustainability and how it relates to their discipline. Engineers should be able to bring this knowledge to their work. Engineering faculty should be able to bring this knowledge to their teaching, research and service, but not in a piecemeal fashion. There must be a whole sale embracing of this new approach to engineering education. Engineering students must to be ready to face global challenges today and tomorrow. They must understand how to work and solve problems in a global world. Are you prepared in your profession to solve global challenges in a sustainable way? Are you prepared to teach your students how to solve global challenges in a sustainable way?

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