Create, Innovate, and Educate: Integrating Sustainability into Engineering Education

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Abstract

This paper highlights an international, interdisciplinary course that seeks to integrate sustainability into the engineering education curriculum through a course entitled GO GREEN (Green Organizations: Global Responsibility for Environmental and Economic Necessity). This course helps to *create* new knowledge for students by stressing the interconnected aspects of financial, social, and environmental stewardship in organizations. Additionally, GO GREEN *innovates* through experiential site visits, applied undergraduate research, and service learning. Finally, the course seeks to *educate* students from the disparate-yet-connected disciplines of design, engineering, manufacturing, technology, and leadership. Now in its fifth year, GO GREEN relies heavily on industry-education partnerships. Such partnerships with business, industry, government, and academic enterprises help to bring the concepts of sustainability alive for students in engineering education. Faculty from varying disciplines support the teaching, research, and service endeavors related to the course. Institutional support for travel, logistics, and program components is also essential to GO GREEN's success.

The GO GREEN Course

The GO GREEN course was developed specifically for engineering and technology students to teach them about sustainable development by looking at best practices in business and industry using real world examples. (For the purposes of this paper we will use the generally accepted definition of "sustainable development,' which is to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.[1])

The GO GREEN course has three distinct parts:

- A portion of the course is taught at Indiana University-Purdue University Indianapolis (IUPUI) an urban research university with nearly 30,000 students in Indianapolis, Indiana, prior to the trip to Germany.
- A portion is taught through experiential learning at site visits during a one-week field experience in and around Mannheim, Germany, in conjunction with five or more German industrial, municipal and/or academic partners.
- A portion of the course is taught at IUPUI after the group returns from Germany.

What makes this undergraduate course special is the partnerships with German industries in order to highlight best practices of sustainable development for student learning. The field experience in Mannheim includes lectures to students by industry partner hosts, lectures and/or

discussions by other company representatives, and tours of various parts of the industry. The involvement of these generous German industry partners has allowed this course to flourish.

The GO GREEN one-week study abroad course in Germany includes industries like; ABB, BASF, DaimlerChrysler, MVV Energie, SolarFabrik, Roche, Bayer and/or towns and villages, such as; Ladenburg, Freiburg and Vauban. All of these industries, small towns, villages, and cities are studied for their sustainable processes and practices. In addition, sustainable case studies are used in the course. Students conduct research on industries, towns, villages and cities they visit and conduct comparisons of similar entities in the United States. Students write a comparison paper focusing on three of these entities looking at sustainable and global practices along with company's mission, vision, product, customer base, etc. Students also write a culture paper on their reaction to German aspects of behavior, attitudes, and customs and on the similarities and differences in the lives of Germans and Americans.

The course was designed to be interdisciplinary drawing on the disparate-yet-related disciplines of design, engineering, manufacturing, technology, and leadership. It is co-taught by faculty in fields of mechanical engineering, architectural technology, organizational leadership, and world languages and cultures. While the central focus of the course is sustainability; globalization and German culture are two other important themes. The study of German culture reinforces the concept of sustainability because the Germans have been recycling for many years. In addition, there is an extensive use of an efficient mass transit system consisting of trains, trams, and electric buses in Germany. Walking and bicycling is also very common means of transportation in all types of weather.

The GO GREEN course looks at enterprises whose principles and foundations are based on three equally important issues in decision making; economics, environment, and society. Organizations are taking into account the impact they have on the scarce resources and the effects they have on the planet whether it is the use of water, release of carbon dioxide, partials released into the atmosphere, crude oil pumped from the ground, etc. This use of resources is often referred to as the ecological footprint.[2] In 1996, for example, BASF, a large chemical company developed a tool they call the Eco-Efficiency Analysis.[3] They use this tool which places dollar values on the economics, the environment, and the social aspects of each business opportunity or prospective project. This tool helps BASF decide whether they should take on a project or not. The weights on all three are equal.

The GO GREEN course objectives are as follows:

- Acquire the base knowledge of issues in sustainability as they relate to business and industry internationally and nationally.
- Examine and evaluate case studies of sustainable practices in business and industry.
- Visit international and national industries and organizations that practice sustainability to gain first hand knowledge of operations.
- Identify trends and business practices in various sustainable organizations.
- Utilize information from course to apply sustainable knowledge in the workplace upon return.
- Acquire some knowledge of German culture and language

Students leave the GO GREEN course with generally new knowledge in an issue that they can apply to their discipline.

GO GREEN has evolved to emphasize both undergraduate education *and* undergraduate research opportunities related to sustainability via two 3-credit hour learning experiences (3-credit course-based experience; 3-credit research-based experience). Some students participate in the one-week GO GREEN course, and then add a field-based undergraduate research component that permits them to spend additional time in Germany conducting applied research in the area of sustainability.

Why Study Sustainability?

Sustainable Development is a contemporary issue for all of society to embrace, especially engineers. Sustainability does have the attention of engineering groups all over the world; however, the concept has not been mainstreamed in engineering education within the United States. Several engineering societies within the U.S. have made declarative statements about their commitments to sustainable development. In 2002, the American Association of Engineering Societies, American Institute of Chemical Engineering, and American Society for Mechanical Engineers International–Environmental Engineering Division made a declaration on behalf of these organizations to the World Summit on Sustainable Development held in Johannesburg, South Africa, to commit to creating a sustainable world.[4] 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." [5] Even 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 (ASEE), 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.[6] While all of this is a good start, there still is a lack of knowledge of this subject matter in general amongst engineering educators and thus within the engineering education system. However, this is not the case in Europe. Sustainable development is common in industry and in every day life, and most common in Germany.

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. 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, in the past and now, is the failure of a company to include the cost of replacing the product or process it takes from the earth.[7] In the EU and Germany these kinds of costs are routinely taken into account along with the costs to society. The "triple bottom line" 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 "ecosense" 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.

Instead of throwing products away at the end of their life cycle to find their way to landfills, many countries in the European Union (EU) now have legislation[8], which forces the producers of products to be the disposers of those same products at the end of their life. And with many countries left with no more landfills, this change has forced innovation in product design and development, thus, reducing waste and pollution at all points by having a product's end-of-life become another new product or become a part of another product or be recycled.[9]

William McDonough, an architect who focuses on sustainability in his own work, coined a strange phrase "waste equals food," which means the waste or end-of-cycle product should become the "food" or all or part of some new product. A simple example of "waste equals food" is a "Waste to Energy" facility that turns garbage into energy. In this example, waste is the garbage and energy becomes heat and/or power –the food. McDonough also coined the term "cradle to cradle" which he uses when he talks about a product's life cycle. He professes that everything now and in the future must be designed so that the products, packaging, systems, processes, etc., has no waste. In other words, we eliminate the "cradle to death" life cycle, which has been practiced and taught since the industrial revolution.[10]

The concept to eliminate all waste is one that most German individuals follow. And one of the common sustainable practices of all German industries, cities, towns, and villages that the GO GREEN class visits is to eliminate waste. The Freudenberg Group, a German family owed company (and a GO GREEN partner) grew a new business out of their scraps from their original business. Freudenberg's first business was a tannery company that also made leather shoes. Literally, from the scraps of the leather shoes, they made seals from the leather and started a new business, which eventually became successful on its own. This is an excellent example of 'waste equals food' over 80 years ago.

Why Study Sustainability in Germany?

German industries were chosen as best practices for sustainable development for several reasons. First, Germany is recognized as a leader in the area of sustainable practices – even within the European Union (EU) – and has been actively engaged in instituting environmental policies for over thirty years. Sustainable efforts began in Germany with the 1972 Paris Summit where European Heads of State and Governments started working on environmental issues. The Amsterdam Treaty, ratified May 1, 1999, gave environmental issues the legal basis it needed to take hold in Europe; thus, the promotion of sustainable development in the European Union became an important issue in the European Commission Treaty. Nearly 200 legal acts cover all areas of the environment within the Treaty. As part of the European Union, Germany is a leader in economic sustainable development and practices in business and industry. In fact, Germany and The Netherlands both have been credited with using new methods and tools to strengthen their government's policies and regulations aimed at improving environmental performance in industry and products. These countries' governments have played a leading role in decreasing

greenhouse gas emissions, increasing water and energy efficiency, developing renewable energy resources, and eliminating waste and/or resource recovery.

In addition to Germany having a long history of laws and regulations of environmental practices another reason for taking GO GREEN to Germany was IUPUI's long-standing partnership with the Berufsakademie Mannheim. Since 1990, IUPUI and the Berufsakademie Mannheim have participated in cooperative education endeavors in which students and faculty work on internships or applied research projects in and around the communities of the host campus. The relationship with the Berufsakademie permitted IUPUI faculty access to industry partners to facilitate arrangements and opportunities for sustainability-related teaching and research. Faculty at the Berufsakademie coordinated the initial meetings with the appropriate representatives at several German industries. As the course has expanded, other German industries, government, and academic parties have been added as a result of networking at conferences, meetings, as well as our continued partnership with the Berufsakademie Mannheim. Additionally, the Berufsakademie provides faculty and students in the course with space, technology, and other related resources to assist in the teaching, learning, and research processes.

Finally, and perhaps most significantly, Germany provides a dynamic, experiential learning laboratory to equip GO GREEN students with an understanding of global perspectives via examples through our partners. This is important because the engineering professional of today and tomorrow must be able to work in an environment increasingly characterized by the changing nature of international trade the use of new innovative technologies, materials and processes that inform research and practice; the growth of information technology; the complex interactions across many disciplines; the need to understand real world engineering systems; and the ability to grasp global issues and to work with culturally diverse people.

Industry-Education Partnerships

The GO GREEN course would not be possible without the German and U.S. industry, municipal/government, academic partnerships. These partnerships were formed through introductions by the Berufsakademie Mannheim faculty or through networking and meetings with individual parties.[11] There are no formal memorandums of understanding (MOU) or contracts with any of these industrial or municipal partners. The only MOUs are with our academic partners. Only a simple understanding of friendship and willingness to work with GO GREEN faculty in teaching students about sustainable practices and processes at their facility or location exists between the two parties. However, there is a fair amount of communication between partners during the year. The following are our GO GREEN partners:

- ABB – Ladenburg, Germany
- BASF – Ludwigshafen, Germany
- Berufsakademie Mannheim – Mannheim, Germany
- Bodensee-Wasserversorgung –Water Company for the State of Baden-Württemberg in Stuttgart and Lake Constance, Germany
- City of Freiburg and FraunhoferInstitute – Freiburg, Germany
- City of Landenburg – Landenburg, Germany
- Daimler-Chrysler – Rastatt, Germany
- Fraunhofer Solar Institute – Freiburg, Germany

- Freudenberg – Nora Rubber -Weinheim, Germany
- Garforth International LLC – Energy Productivity Solutions – Toledo, Ohio and Brussels, Belgium
- Interface Incorporated – Atlanta, Georgia
- MVV Energie- Mannheim, Germany
- PortionPac – Chicago, IL
- Rolls Royce, Indianapolis, IN
- SolarFabrik – Freiburg, Germany
- University of Applied Sciences at Magdeburg- Magdeburg, Germany
- University of Kaiserslautern, Kaiserslautern, Germany

This is a very diverse group of industries, government, and academic enterprises. Not all of these entities can be visited each year; roughly 5 to 6 are used annually. Our future goal is to offer GO GREEN several times a year and, therefore, we are always looking to add additional partners.

Each year, a report of the summary GO GREEN project activities is given to the partners. It includes a list of course related papers, books, presentations, and projects authored, co-authored or presented by faculty and/or students. It also includes course related undergraduate sustainable research projects, service learning projects, grants, and other related international activities. The booklet contains course related information, student comments taken from student papers and other pertinent information. The goal is to keep our partners informed of the outcomes from their efforts in this endeavor. This report is used as a "thank you" to them as participants in the education of our students.

Institution Support

GO GREEN's success is due to several factors. The faculty are a diverse faculty group who work well together and have a passion for the subject matter. Most importantly, the dean gives the tuition income to the faculty to run the program. While this amount of funding does not pay for salaries to teach the course, it does almost cover the travel costs for three faculty. There are numerous opportunities working with industry and academic partners. One example of this is our partnership with the University of Kaiserslautern. Our partner there is opening a GO GREEN Center at that institution to specifically work with our project and to expand our activities together. One immediate outcome from this event is that he has invited several of the GO GREEN faculty members to teach in the University of Kaiserslautern's new sustainable masters program which will be taught in English. This is a valuable opportunity for a young faculty member to establish an international reputation and for more established faculty this is an opportunity to develop a new area of research or scholarship.

In addition, the institution has supported the GO GREEN project with funds for the sustainable undergraduate research projects. The program has received $20,000 for three consecutive years.[12] In the summer of 2007, we are adding a service learning component to the course and will hope to have some funding for students for this part of the course, however, this is to be determined.

Conclusion

GO GREEN gives students the ability to learn about sustainability, globalization, and German culture. It also affords U.S. students an opportunity to travel abroad and to experience first hand a difference culture. This is a valuable learning experience, one that can not be duplicated in a classroom or on-line. The course is also valuable in an engineering and technology student's education because it provides a look at two contemporary issues (sustainability and globalization) over multiple disciplines (design, engineering, manufacturing, technology, and leadership) and how these issues are dealt with in international business, industrial, and municipal settings. The role of the industry-education partnership is extremely important to this course. The German industry partners are critical to the existence and the continuation of the GO GREEN program. Continuous communication with these partners is important for maintaining their support. The faculty from varying disciplines that support the teaching, research, and service endeavors in the GO GREEN course are successful because they share the responsibilities and work collegially and cohesively. They are supported by the university and their administration.

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