
AC 2012-4112: SUSTAINABLE ENGINEERING INTERNSHIPS: CREATION AND ASSESSMENT

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Sustainable Engineering Internships: Creation and Assessment

Abstract

Engineering Sustainable Engineers, a program sponsored by National Science Foundation (NSF), was designed to improve undergraduate student knowledge of and competency in addressing sustainability issues in engineering design and problem solving. The program involves collaboration among faculty in Civil, Industrial, and Mechanical Engineering at the University of Texas at Arlington. One of the key program elements is placing students in their junior or senior year with companies using exemplary sustainable design and operation practices. The internships expose students to development of solutions that mitigate potential negative impacts on sustainability.

To identify companies with exemplary sustainable design and operation practices, the project team created a “Quality Sustainable Engineering Internship Survey” via Survey Monkey, which was sent to over 250 companies that hire engineers in the Dallas-Fort Worth area. The paper will present the survey questions and their rationale, to aid other universities that may want to conduct similar surveys in their own region. Six students were placed in paid internships with the four companies, over two summers. The paper will describe the student-company internship matches that were created. To encourage companies to participate, \$2000 was made available from the NSF grant to support each student’s internship

To evaluate the effectiveness of the internships in achieving project objectives, each student completed a survey at the end of his/her internship to assess the impact of the experience. Company representatives also completed a survey, with the goal of collecting information to improve future internship experiences. The paper will summarize survey results.

Introduction

Sustainability has been identified as one of the global grand challenges of the 21st century. In order for future generations to enjoy a satisfactory quality of life, the current generation must find ways to meet humanity's needs for energy, shelter, food and water in ways that are environmentally, economically, and socially sustainable.

Sustainable engineering may be defined as engineering for human development that meets the needs of the present without compromising the ability of future generations to meet their own needs.¹ Due to population growth and expanded global development, the next generation of engineers must be able to design with fewer resources for a wider variety and greater number of end users.² According to National Academy of Engineering (NAE) President Charles M. Vest, macroscale issues of great societal importance, like energy, water, and sustainability, will dominate 21st century engineering.³ According to the NAE report *The Engineer of 2020*, engineers of the future must gain a holistic understanding of sustainable economic growth and development, in order to solve society’s pressing environmental problems.⁴

To educate undergraduate engineering students about sustainable engineering, and specifically to improve their knowledge of and competency in addressing sustainability issues in engineering design and problem solving, the Engineering Sustainable Engineers program was started at the University of Texas at Arlington, with support from the National Science Foundation. The program involves collaboration among faculty in Civil, Industrial, and Mechanical Engineering. Program elements include:

1. Sustainability Learning Modules, incorporated into 17 undergraduate engineering classes,
2. Multidisciplinary Senior Design Project, and
3. Sustainable Engineering Internships.

The program components, taken collectively, are designed to expose engineering students repeatedly to sustainability concepts during their undergraduate education. Components 1 and 2 are discussed elsewhere.⁵⁻⁹ This paper discusses Component 3, Sustainable Engineering Internships.

Sustainable Engineering Internships move the students beyond classroom experiences, exposing them to development of real-world solutions to mitigate negative impacts of engineering designs on sustainability. Students would typically be placed in sustainable engineering internships during their junior or senior year.

Objectives

The objectives of the work described here were:

1. To develop a survey for identifying companies that would offer a quality sustainable engineering internship,
2. To place students in meaningful internships,
3. To evaluate the effectiveness of the internships.

Methods

Methods for Identifying Companies. The project team developed a survey that was used to identify companies likely to provide quality sustainable engineering internships. Such companies must incorporate sustainability issues into their design and/or production processes. For example, the existence of a comprehensive waste reduction and recycling program at a company would be commendable, but would not necessarily help an intern learn more about sustainable engineering design. The “Quality Sustainable Engineering Internship Survey,” shown in Figure 1, was created using Survey Monkey. The survey is posted on the project web site at <http://www.uta.edu/ce/ese/Internship%20Options.htm> for other universities to use. Motivation behind the survey questions is given in Table 1. A question that allowed the company to express its preference for a particular engineering major would have added clarity to our survey.

Figure 1. Quality Sustainable Engineering Internship Survey

Sustainable Internship Company Survey Ex

1. Begin your survey

1. Company Information:

Name of the company:

Email:

Telephone No:

Contact person:

2. Approximately how many employees are employed at your facility?

3. How many employees work full-time in environmental protection at your location?

4. Would your firm accept international students (non-US) for internships?

YES

NO

5. Describe the roles and training that your firm provides to engineering interns, if any.

6. Sustainable engineering may be defined as engineering to meet human needs of the present without compromising the ability of future generations to meet their own needs, including environmental protection.

a) Does your current internship program expose students to the development of solutions that mitigate potential negative impacts on sustainability?

YES

NO

7. Refer to question # 5, Would your firm consider having this be a goal associated with the student's internship experience?

YES

NO

Figure 1. Quality Sustainable Engineering Internship Survey (continued)

8. Aspects of sustainability that your firm may consider (Sustainable Internship Company Survey <http://www.surveymonkey.com/s/BBVDNCS>) are listed in the table below (left-hand column). Stages of a product's life cycle (from manufacturing to use to disposal) are listed in the table below (top-hand column). In the table, put a check in boxes to indicate that your firm considers a certain aspect of sustainability related to a certain part of your product's life cycle. For example:

In designing a product, does your firm try to minimize the energy that it will take to manufacture that product? If so, you would put a check in the "Energy use"/"Manufacturing" box.

In designing a product, does your firm try to minimize the energy that the product will consume during its use by a consumer? If so, you would put a check in the "Energy use"/"Use" box.

Life Cycle Stage →	1. Material Acquisition	2. Manufacturing	3. Transportation	4. Use	5. End of Life
Sustainability Aspect ↓	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Material use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Solid waste generation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Emissions generation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Toxic releases	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. Land impact	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9. Give an example of consideration of sustainability in product design at your firm.

10. Why do you think your firm would be a good choice to sponsor a sustainable engineering internship?

Done

Survey Powered by:
SurveyMonkey
 "Surveys Made Simple."

Table 1. Rationale for “Quality Sustainable Internship Survey” Questions

Question	Motivation
1	Basic company contact information
2	Information about whether the company is small or large
3	We wanted to know how many employees were engaged in full-time environmental protection, because we thought that the presence of such employees would indicate a serious company commitment to sustainability.
4	Many of our students are international, so opportunities for their employment would be advantageous.
5	We were looking for companies that provided interns with meaningful engineering work, and ideally provided training.
8	The more metrics of sustainability that a company considers, and the more life cycle phases that a company considers in design of its products/structures, the more we would consider that company a model of exemplary sustainable engineering practice.
9	Requests a specific example of the general information requested in Question 8.
10	Allows companies to provide additional information not already given in response to another question.

The university’s College of Engineering Internship Coordinator provided the project team a list of over 250 companies that hire engineers in the Dallas/Fort Worth area. An e-mail was sent to the companies inviting them to complete the survey; follow-up phone calls were also placed to several target companies. To encourage companies to participate, \$2000 was made available from the NSF grant to support each student’s internship, which the company was then free to supplement.

Methods for Placing Students in Internships. Interested students submitted an internship application explaining their interest in sustainability and how they believed they would benefit from the internship. The application form is available to interested parties from the authors. Internships were publicized via e-mails to students and posting of flyers.

The project team reviewed student applications and identified a short list of top candidates. The applications of these top candidates were then forwarded to the company representatives. Company representatives reviewed the applications, and then conducted phone and in-person interviews with promising candidates. The companies then extended an internship offer to the student of their choice. Hiring was done directly by the company.

Methods for Assessing Internship Effectiveness. Internship effectiveness was assessed via surveys given to participating students and company representatives. Student oral presentations concerning their internship experiences were also evaluated, since improvement in student communication skills was one of the overall project objectives.

Results and Discussion

Internship Matches

Survey responses and informal follow-up phone interviews were used to select 4 companies with exemplary sustainable design and operation practices to participate in the internship program:

- **Kimley-Horn and Associates.** This civil engineering consulting firm specializes in land development, transportation, environmental services, and surface water resources. Willing to hire civil engineering interns.
- **Facility Performance Associates.** This consulting firm specializes in LEED (Leadership in Energy and Environmental Design) project delivery. Willing to hire civil and mechanical engineering interns.
- **PepsiCo.** The plant that manufactures concentrate used in Pepsi soft drink products is located in Arlington, Texas. Willing to hire industrial and mechanical engineering interns.
- **Kroger Manufacturing, Vandervoort Dairy.** The plant that packages milk products (e.g. milk, yogurt, cottage cheese) for Kroger grocery stores in Texas is located in Fort Worth, Texas. Willing to hire civil, mechanical, and industrial engineering interns.

The above companies were selected based on their survey responses, which demonstrated that they were actively considering sustainability in their product/facility design and construction/production. They were also willing to hire engineering students in the disciplines participating in the Engineering Sustainable Engineers program.

Following review of student applications and coordination with company representatives, four students were placed in internships with the companies during Summer 2010, as shown in Table 1 below. During Summer 2011, two students were placed in internships. Our NSF proposal stated that we would place at least five students in internships, and we ended up placing six.

Three departments participated in the Engineering Sustainable Engineers program: Civil Engineering, Industrial Engineering, and Mechanical Engineering. We had hoped to place equal number of students from each major in internships, but ended up placing primarily civil engineering students. Several industrial engineering students accepted internships with other companies before being matched in a sustainable engineering internship. We did not have a faculty member actively recruiting students in mechanical engineering, and thus received few mechanical engineering applications.

Table 2 briefly summarizes the nature of the sustainable engineering work that each student performed. The nature of the work that the students performed met our expectations in terms of the students being involved in actual sustainable engineering design and decision-making.

At the middle of the internship and at the end, each student submitted a report that described their work in more detail, and explained impacts of their projects/designs on sustainability. The PI provided feedback to students concerning the reports. This helped fulfill the project objective of improving student written communication skills. The reports are available from the PI.

Each intern chose a faculty mentor to monitor the internship activities. Mentors were to resolve any conflicts arising between the intern and the company, and to ensure that the intern submits his/her reports. The mentors proved unnecessary, and will not be used again in future programs.

It should be noted that in two cases, the intern's work included an economic evaluation. We were pleased with this, since sustainable solutions should be sustainable not only in terms of the environmental but also in terms of the economy (and society).

Table 2. Sustainable Engineering Internship Matches

Year	Company	Student	Student's Major	Nature of Sustainable Engineering Work	Faculty Mentor
2010	Kimley-Horn and Associates	Evan Young	CE	Development design using techniques to reduce stormwater runoff quantity and improve quality; mixed use development design	Yvette Weatherton
2010	Facility Performance Associates	Sandip Tamrakar	CE	Review of sustainable building designs for LEED certification	Melanie Sattler
2010	PepsiCo	Amy Morris	IE	Identification of ways to change production process to save water	Jamie Rogers
2010	Kroger Manufacturing (Vandervoort Dairy)	Manuela Arroyo	CE	Identification of ways to change production process to reduce water and energy consumption. Cost-benefit analysis of solar power for one part of production process.	Yvette Weatherton
2011	Facility Performance Associates	Sandip Tamrakar	CE	Review of sustainable building designs for LEED certification	Melanie Sattler
2011	Kroger Manufacturing (Vandervoort Dairy)	Amanda Gentry	CE	Identification of ways to facilitate recycling, reduce water consumption, and energy consumption, including economic evaluation.	Melanie Sattler

Internship Assessment: Surveys

Each student completed a survey at the end of his/her internship to assess the quality of the experience. Multiple-choice survey question responses from students are presented in Table 3.

Table 3. Student Surveys – Sustainable Internship

Question		To a great extent	To a moderate extent	To a small extent	Not at all
1	The internship increased my ability to explain sustainability concepts and terminology.	4 67%	2 33%	0 0%	0 0%
2	The internship increased my ability to recognize impacts of engineering project/designs on sustainability.	4 67%	2 33%	0 0%	0 0%
3	The internship increased my ability to identify mitigation strategies for reducing negative impacts on sustainability.	2 33%	4 67%	0 0%	0 0%
4	The internship increased my ability to evaluate potential engineering solutions based on sustainability.	4 67%	1 17%	1 17%	0 0%
5	The internship increased my ability to work effectively in multidisciplinary teams.	4 67%	2 33%	0 0%	0 0%
Question		Strongly Agree	Agree	Disagree	Strongly Disagree
6	Participation in the internship will make me more likely to consider sustainable design options in my future career.	5 83%	1 17%	0 0%	0 0%
7	I would recommend future students to participate in sustainable engineering internships.	6 100%	0 0%	0 0%	0 0%
TOTAL		29 69%	12 29%	1 2%	0 0%

Student responses to short-answer survey questions are listed below.

What was the best aspect of the sustainable engineering internship?

- Being able to work in teams with experienced engineers
- Being able to identify areas of improvement and take the initiative to start process improvement
- Being able to understand what sustainability is, and how it impacts consumer products
- Exposure to “real world” applications of coursework
- Working with the engineers of other disciplines; saw how all the engineers work as a team.

- I got to work on a project that will help reduce water and energy. This will help me a lot in the future when I get to design my own projects. This internship also helped me gain experience in the engineering field.
- Seeing the relationship between business and sustainability. There is a very strong need for sustainability options to be economically sound. This program was great to see this at a hands-on level.
- Working in a multi-disciplinary firm gave me a good idea of how engineering teams work to make new projects sustainable. Hands-on training on available tools to meet today's challenges in making buildings sustainable was most important for me.

What aspect of the sustainable engineering internship needs the most improvement, if it were to be offered again?

- General outline/guideline for reports
- Rubric for presentation
- More information on the program prior to application
- Communication between other students who are also working as sustainable engineering interns.
- Have students take an environmental class (prior to participating in the internship), because I found that class very useful while I was working.
- Assuring that the company has staff members available to guide interns and assist in developing sustainability options.

Survey responses show that the students feel that the internships increased their ability to explain sustainability concepts, recognize impacts of engineering projects on sustainability, and identify mitigation strategies for reducing negative impacts on sustainability. The internships also increased their ability to work effectively in multidisciplinary teams. Particularly encouraging are the responses that students will be more likely to consider sustainable design options in their future career, with five students strongly agreeing and one student agreeing. All six students strongly agreed that they would recommend the sustainable internships to other students.

Company representatives completed a separate survey, with the goal of collecting information to improve future internship experiences. Multiple-choice survey question responses from company representatives are presented in Table 4.

Table 4. Company Surveys - Sustainable Internship

Question		Strongly Agree	Agree	Disagree	Strongly Disagree
1	I was pleased with the number of resumes sent to me for review.	2 50%	0 0%	1 25%	1 25%
2	I was pleased with the quality of resumes sent for me to review.	2 50%	1 25%	0 0%	1 25%
3	I was pleased with the quality of work performed by the student intern.	2 50%	0 0%	2 50%	0 0%
Question		To a great extent	To a moderate extent	To a small extent	Not at all
4	The stipend was an incentive for my company to participate in this program.	1 25%	1 25%	2 50%	0 0%
Question		Strongly Agree	Agree	Disagree	Strongly Disagree
5	Program goals and expectations were clearly communicated.	2 50%	2 50%	0 0%	0 0%
6	I would like to participate in this program again next summer.	4 100%	0 0%	0 0%	0 0%
7	I would recommend this internship program to other companies.	4 100%	0 0%	0 0%	0 0%
TOTAL		17 61%	4 14%	5 18%	2 7%

Company representative responses to short-answer survey questions are listed below.

What was the best aspect of the sustainable engineering internship?

- Opportunity to expose future engineers to a world class sustainability approach and strategy
- Win-win situation, additional person resource semi-qualified for the company/company has the opportunity to instruct and in turn gain fresh ideas forcing us to look at processes differently.
- Help provide valuable experience and exposure to the student; was a symbiotic relationship for the student and company.
- Having the opportunity to bring fresh ideas and young minds into our organization, along with their level of enthusiasm.

What aspect of the sustainable engineering internship needs the most improvement, if it were to be offered again?

- Involve company rep in student selection process
- Increase time frame or length of internship
- Look for long-term opportunities for 1-2 year sustainability internships.
- Was done well and appreciated the opportunity to participate. We learned some valuable lessons – would like to participate again so we have an opportunity to grow with the program.
- The student should devote more time to the program and should not be enrolled in summer classes.
- Would like milestone surveys sent directly to the employer instead of going through the student. Also, copies of the reports the students complete.

The fact that all companies want to participate in the program again and would recommend the program to other companies is positive. The company survey responses offer helpful ideas for improvement of future internship programs. One company was not satisfied with their student's performance; this student was taking classes in addition to pursuing the internship, which meant less than full-time work on the internship. In the future, we will specify during the application process that the internship is a full-time commitment.

Our hope is that these initial internships will initiate long-term partnerships that will enable the internship program to continue. In this vein, we plan scheduled a tour of the Kroger Manufacturing facility during the fall semester for members of the UT Arlington student chapter of the Air & Waste Management Association.

Internship Assessment: Student Presentations

One of the objectives of the overall Engineering Sustainable Engineers program was improving student communication skills. To help achieve this objective, students participating in an internship were given the opportunity to give and receive feedback on an oral presentation. At the end of each summer, a seminar was held, at which each student presented one of his/her reports. Students, company representatives, and faculty mentors attended the seminar, and used a rubric to assess the student presentations.

Results from these assessments are provided in Table 5. We feel that the student presentations were acceptable, especially considering that this may have been the first opportunity to give a presentation for some of the students. According to the data in Table 5, the following areas had more than 20% of responses as neutral or disagree, indicating particular room for improvement in the presentations:

- Demonstrating that student could use sustainability as a criteria in choosing among engineering alternatives.
- Using gestures where appropriate.

In addition, avoiding use of filler words like “um” had the least number of “strongly agree” responses, indicating another area for improvement. One strategy for improving future student presentations will be to provide students with the rubric ahead of time, to give them ideas about what makes for good presentation content and communication effectiveness.

Table 5. Evaluation of Student Internship Presentations

Questions - Presentation Content		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	The presentation demonstrated that student could recognize potential negative impacts of engineering designs on sustainability.	17 38%	22 49%	3 7%	3 7%	0 0%
2	The presentation demonstrated that student could identify ways to mitigate potential negative impacts on sustainability.	17 38%	26 58%	1 2%	1 2%	0 0%
3	The presentation demonstrated that student could use sustainability as a criteria in choosing among engineering alternatives.	18 40%	17 38%	7 16%	3 7%	0 0%
4	The presentation contained an appropriate introduction.	20 45%	18 41%	5 11%	1 2%	0 0%
5	The presentation was well-organized.	19 42%	21 47%	3 7%	2 4%	0 0%
6	The presentation contained an appropriate conclusion.	16 36%	21 47%	5 11%	3 7%	0 0%
Questions - Communication Effectiveness		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7	The format of the PowerPoint slides was clear and easy to read.	23 51%	19 42%	2 4%	1 2%	0 0%
8	The student spoke loudly enough.	24 53%	19 42%	2 4%	0 0%	0 0%
9	The student spoke at an appropriate pace (not too fast or too slow).	22 49%	22 49%	1 2%	0 0%	0 0%
10	The student made sufficient eye contact with the audience.	24 55%	15 34%	3 7%	2 5%	0 0%
11	The student avoided using filler words like “um”.	12 27%	27 60%	3 7%	3 7%	0 0%
12	The student avoided simply reading text from the slides, but instead explained material.	23 51%	15 33%	5 11%	2 4%	0 0%
13	The student used gestures where appropriate.	14 31%	20 44%	9 20%	2 4%	0 0%
TOTAL		249 43%	262 45%	49 8%	23 4%	0 0%

Conclusions

A “Quality Sustainable Engineering Internship Survey” was created via Survey Monkey and used to identify four companies with exemplary sustainable design and operation practices. Six students were placed in internships with the four companies, over two summers. The nature of the work that the students performed met our expectations in terms of the students being involved in actual sustainable engineering design and decision-making. Survey responses show that the students feel that the internships increased their ability to explain sustainability concepts, recognize impacts of engineering projects on sustainability, and identify mitigation strategies for reducing negative impacts on sustainability. The fact that all companies want to participate in the program again and would recommend the program to other companies is positive. Our hope is that these initial internships will initiate long-term partnerships that will enable the internship program to continue.

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