TEACHING FRESHMEN THE NEED FOR SUSTAINABILITY IN THE NEW MILLENNIUM

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Abstract *— When you look at the freshman curriculum, most engineers believe it is necessary for the student to learn proper writing, mathematics, physics and chemistry skills. However, there is also an interest in teaching the concept of Sustainability to students as soon as the freshman year. The problem is how to add material and content to a curriculum that is already full. To address this problem the University of Pittsburgh began teaching Sustainability to the entire freshman class in Spring 2000, by incorporating the concept of Sustainability into the students Introduction to Engineering Course through the concept of writing to learn.*

The educational benefits of adapting a writing approach in the classroom have been widely documented. Writing can serve as a tool to improve the quality of teaching as well as to promote deeper and more meaningful student learning. In this paper we will explore strategies in which writing can be used to both introduce the concept of sustainability and enhance student understanding in introductory engineering courses. To accomplish this goal, students were asked to prepare and present a professional research paper for a "conference". Highlights of the curriculum developed will be discussed. Through a description of the curricula and strategies developed, we hope to provide other science and engineering educators with useful tools to assist them in developing and/or enhancing the use of writing within their own classrooms.

INTRODUCTION

Traditional teaching methodologies have been shown to put students in a role of passive rather than active learning [1]. In addition, traditional instructional methods have also been shown to be very inadequate in terms of the promotion of deep learning and long-term retention of important concepts. Students in traditional classrooms acquire most of their "knowledge" through classroom lectures and textbook reading. A troubling fact is, after instruction, students often emerge from our classes with serious misconceptions [2 - 6].

A significant body of educational research supports the fact that students must be functionally active to learn [7 - 9]. Furthermore, Koballa, Kemp, and Evans [10] note that "ALL students must become scientifically literate if they are to function in tomorrow's society". Scientific literacy is of critical importance for all students at all educational levels.

The *National Science Education Standards* [11] strongly emphasize that inquiry-based techniques should form the core of what it means to learn and do science. Edwards [12] suggests that the publication of the *National Science Education Standards* offer reason to be optimistic that inquiry-based learning will become a central part of science education. Inquiry-based learning strategies originate from the constructivist model and encourage an active, hands-on approach to learning [13 - 14]. The constructivist approach embraces the idea that knowledge cannot be acquired passively [15]. In addition, the National Science Foundation currently has several programs that promote the integration of standards and inquiry-based SMET educational materials and instructional strategies from elementary through graduate school [16].

In recent years, a number of writing techniques have evolved that make use of various writing-to-learn strategies within the domains of engineering, mathematics, and the sciences [17 - 25]. The use of writing in introductory classes may be an effective vehicle for allowing students to enhance their critical thinking and problem-solving skills. Writing can also assist students with the identification and confrontation of personal misconceptions [26, 27].

Science classes are seen by many students to be threatening and intimidating places to be. Tobias [28, 29] also indicates that writing can serve as a means to help students relieve their anxiety and help them unlearn models and techniques that have been shown to be scientifically unsound.

This article describes a novel technique for infusing the concept of sustainability into the freshman engineering curriculum that is based on research the authors are conducting on using writing as a means of providing "hands on learning". [31 - 35]. The techniques to be described here permit students to experience all aspects of preparing a professional paper for publication. The students' experiences culminate with a presentation of their papers at the *Sustainability in the New Millennium Conference* at the University of Pittsburgh. The writing technique was initially modeled at American University then adapted for use at Pittsburgh [36]. The specific courses in which the writing

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strategies were adapted, *Introduction to Engineering Problem Solving*, will first be described. The curriculum involved in the development of the writing activity will then be discussed. This discussion will be followed by a summary of the conferences in which students participated. Feedback from student participants will also be shared. In addition, lessons learned during the initial phase of the study will be shared along with how those lessons translated into effective changes for this year. Finally, a summary of this technique will be presented in light of its relevance to science, mathematics, engineering, and technology (SMET) education.

Since the population in the classroom is freshman, their knowledge of sustainability is very limited. In fact the vast majority of the students have never been exposed to the concept. This factor highlights the importance of this assignment and explains why as part of the freshman course syllabus, we must take time away from the typical freshman engineering topics and replace it with a definition of sustainability. Since this program is for all freshman regardless of their major, another concern is the presentation on sustainability must be such that a Civil, Bio or Computer Engineering student will get enough information to develop a definition they can understand. Thus, the first task is to define sustainability.

WHAT IS SUSTAINABILITY

Since the advent of civilization, engineers have sought to alter the environment and shape it in ways that would serve the various needs of society. While our lives today can attest to the success of this endeavor, it has not been without cost. Often times, the alteration of the environment - whether purposeful or unintentional - has led to undesirable consequences. Only in the past several decades have engineers become acutely aware of the consequences of their actions on the environment and society. As a result, growing public demand has led to various legislative and regulatory actions attempting to minimize the adverse consequences of civilization on the environment. Unfortunately, many of these measures - such as the "no net loss" of wetlands policy and the industrial restrictions placed on various parts of the US classified as air pollution "non-attainment" region - often have negatively impacted growth and development. A seeming contradiction between development and environmental protection exists.

In recent years, however, a realization has developed that both development and environmental protection are necessary and that either need not be sacrificed for the other. A growing movement recognizes that environmental protection can and must co-exist with development and must be planned for accordingly. Under the general umbrella of "sustainability", this movement encompasses various facets. "Green Engineering", "sustainable development", "environmentally conscious manufacturing", and "green construction" are some of the terms recently entering the engineering lexicon that describe the move towards sustainability. The confusion surrounding sustainability, is each of these terms means different things to different people. Whether constructing a new highway, designing a new product, or improving a manufacturing process, sustainability issues are at the forefront of challenges today's engineers must face.

What exactly, is meant by "sustainability"? The 1987 Brundtland Report, prepared for the UN's World Commission on Environment and Development, defines it as "satisfying the needs of the present generation without compromising the ability of future generations to meet their own needs"[37]. The 1992 UN Rio Conference on Environment and Development [37] offers a slightly modified version, describing "sustainability" as follows: "the right to development must be fulfilled so as to equitably meet development and environmental needs of present and future generations". Other organizations and individuals propose somewhat different definitions of sustainability. Through all the differing descriptions, however, a common thread remains: sustainability seeks to minimize our footprint in nature, both now and in the future.

Most issues revolving around sustainability, quite naturally, involve subjects traditionally thought of as environmental. These include conventional environmental engineering topics such as waste minimization, pollution prevention and control, and water/wastewater treatment. A second set of issues revolves around energy/resource conservation. It incorporates such items as recycling, alternative fuel sources, alternative fuel vehicles/mass transportation, and energy efficiency. A third group of subjects entails items thought of as environmental ecology. This subset comprises areas such as urban forestry, landscaping and biodiversity.

Although most sustainability issues deal with topics affecting the environment in some manner, one facet of sustainability is unique in that it generally has seemingly little to do with minimizing our footprint on nature, but deals with subjects commonly referred to as "quality of life" issues. Although sometimes not thought of as "sustainability" per se, "quality of life" concerns often are as important, and in some cases, more than the conventionally defined sustainability topics. What exactly is meant by "quality of life"? An admittedly imperfect definition is that they are issues that make human existence more enjoyable, less burdensome, or life extending. Most medical advances, for example, fall under the quality of life definition. These advantages might not impact the environment directly, but often improve human life. Whether it is nano-medicine, nano-probes, new antibiotics, new surgical techniques or new and improved prosthetics, these areas all directly impact the quality of life. Another area of engineering that could be thought of as impacting the "quality of life" is the computer industry. For example, a new piece of software might make it easier to do your taxes, but does not have a direct impact on the environment. There are a large number of other areas

that could fall into the "quality of life" definition. Even thought these areas do not directly impact the environment, all of the products must be manufactured, or operate in a computer that must be manufactured and have environmental issues involved with their production or use. Thus, they directly affect the quality of life and indirectly impact the environment.

The final area of "sustainability" that must be considered is that of "trade offs" or balancing environmental, societal and economic factors. Sustainability becomes a study in benefits versus cost. No panacea exists for sustainability. There are no easy, obvious solutions. Each potential answer to a sustainability concern has potential drawbacks. As an example, assume you design a building to reduce energy consumption by using materials and using building practices that reduce the outside air that enters the building. This will reduce the energy use but also reduce the number of air exchanges in the building and could lead to a "sick building syndrome". A second example is the use of alternate energy sources to generate electricity. Wind and hydroelectric power do not produce greenhouse gases as burning fossil fuels do. However, both have other downsides. Areas favorable to wind are also common migratory pathways for certain birds. When a bird meets a metal turbine, the turbine always wins. Similarly, dams required for hydroelectric power often prevent fish from migrating. Economics also plays a part in sustainability. For example, computers and software development benefits the productivity of the average worker. However, the process used in the manufacture of the microchips presents significant environmental challenges. Environmentally friendlier procedures are available but at an added cost. As a final example, assume that an automaker could produce a car that achieves 100 miles/gallon, but costs $100,000. How many of the cars would be sold?

What is more important? No loss of woodland or more homes and industry? Is energy efficiency more important than indoor air quality - or vice versa? Is it more important to produce clean energy or do the birds and fish take priority? What good is an environmentally safe computer or automobile if no one can afford it? The fact is the population will continue to grow, and energy, food supplies, and habitats will need to keep pace to ensure a consistent and acceptable quality of life. The task for all future engineers will be to balance the quality of life against the environment against the cost to develop the best solution for us and generations that will follow us.

BACKGROUND

All students are required to take four core engineering courses during their first year. There are two zero-credit seminar courses [38, 39] and two three-credit introductory problem solving courses [40] that are a part of this core. ENGR0011 and ENGR0012 are required first and second semester three credit courses, for all freshmen engineers that meets twice a week for 2 hours in a computer-equipped classroom. They are *integrated* courses that have the overall goals of:

1. Teaching the basic computer skills (Excel, Matlab, C), and their role in problem solving,
2. Introducing teamwork,
3. Improving writing and communication skills,
   a. Introduction to Technical Report Writing,
   b. Effective Use of the Library;
4. Promoting and encouraging good programming practices; and
5. Illustrating the role computer programming plays in solving real-world engineering problems, and
6. To begin understanding how material in the basic sciences and mathematics is used by engineers to solve practical problems of interest to society.

It is the experience of the faculty that students know very little about the actual operation of a computer or computer software as problem solving tools. The students are good at using AOL instant messenger, and finding music files on the web, but when it comes to organizing files in directories, or organizing their thoughts into a structured program the vast majority of the students are lost. Thus, the main focus of ENGR0011 is to begin the process of structured thinking then ENGR0012 expands this concept into the structured programming area.

The class sections are taught by faculty members from various departments within the School of Engineering, and the course topics focuses on material that overlaps with various disciplines in engineering. Emphasis is placed on the application of various computer-based tools to solve real-world engineering problems. The course also illustrates how engineering differs from, as well as how it coalesces with, the disciplines of science and mathematics.

In addition to the various activities related to problem solving, students are also exposed to a richer and more robust writing experience in both ENGR0011 and 0012. This experience involves the preparation of a written research paper and oral presentation. These activities will now be described.

DESIGNING THE INTEGRATED LIBRARY RESEARCH PROJECT

To introduce sustainability through the concept of a writing assignment, a communication link had to be installed into the course. This link was in the form of introducing the various word processing software and computer presentation software. Thus, from the students' perspective the writing assignment was a requirement for the communication portion of both courses.

The Spring writing assignment is introduced early in the Fall semester, students were informed that one of the key components of the spring course would be the preparation of

a formal written paper for publication and presentation at a conference to be held at the end of the second semester. Through the context of a conference, students are now introduced to the culture of academic research and the scholarly communication system and how the engineering profession interacts with this skill. Specifically the educational objectives of the library including introduction to some of the library's resources and research processes, and introduction to critical thinking skills to analyze the validity and utility of information are incorporated into the project.

Given that Pitt uses an integrated curriculum approach for their freshman courses, students were told that where possible, their papers should relate to topics covered in the fall or spring semester of their Physics, Chemistry, Calculus or Engineering classes. In addition, students were to link their chosen topics to an area of engineering using the idea of sustainability in the new millennium as the common conference thread. The key idea was to expand upon the concept of curriculum integration by having students merge material from their core courses with material they had learned in their introduction to engineering seminar courses and explain how the product they were researching dealt with the various science topics they were learning and how the engineering profession dealt with the concept of sustainability when designing this product.

To prepare the students for this Spring semester project, it was decided to introduce the students to writing in the Fall semester. It was decided that a trial run of writing and presenting a technical paper to a small group of their peers using PowerPoint software would best prepare the students for the conference in the spring semester. The ENGR0011 faculty agreed that the overall theme of the Fall library research project should focus on the student's exploration of an area of engineering that interested them. Thus, in addition, to the concept of sustainability, the freshman program faculty and advisors wanted the students to be able to answer the question "What is an Engineer"? and how does sustainability fit into every field of engineering?

Each component of the research project included a statement of purpose (or learning objective) so the students would understand why they were doing this work. Research/Resource Guides for each assignment were designed by the library staff in order to supply the students with additional guidance to the resources they would need to consult.

Within the library, the librarians and staff met to discuss the project. A binder containing the Library Research Project was kept at the front desk of the Engineering Library. All of the library staff became familiar with the project; they were aware of which assignment the students would be working on in any given week, as well as the resources students were being asked to access and use.

Throughout the second semester, students were exposed to all aspects involved in the preparation of a formal paper for publication. These aspects included: responding to a call for papers, being notified of the acceptance of their abstracts, conducting the necessary research, preparing and submitting a paper for review, conducting a review, and receiving and utilizing the feedback to prepare a final paper. Each of these items are further described and illustrated in the sub-sections presented below.

The Call for Papers

The conference call for papers was distributed at the beginning of the semester, see Figure 1. Students received a paper copy as well as an electronic copy of the call via the class web page.

Figure 1 Call for Papers

Abstracts are now being accepted for the ***Third Annual Sustainability in the new Millennium Conference*** to be held on **April 5, 2003** at the University of Pittsburgh in Pittsburgh, PA. A wide range of topics will be considered. Where possible, papers should involve some topics listed in the fall or spring semester Physics, Chemistry, Calculus, or Engineering course syllabus.

Possible presentations/paper topics include (but are not limited to):

1) Historical, current, or futuristic views on a physics topic related mechanics, linear, or rotational motion, collisions, energy oscillations, waves, electricity, magnetism, light, color, quantum mechanics, or other topics;
2) Historical, current, or futuristic views on a chemistry topic related to kinetics, entropy, liquids, gases, thermodynamics, materials science, chemical relations, ionic bonding, organic chemistry, polymer chemistry, biochemistry, nuclear chemistry, or environmental topics;
3) Historical, current, or futuristic views on computer science topics related to software development, the internet, programming languages, or other related topics;
4) Physics, computer science and/or chemistry as it relates to the design, development and/or function of a commonly used devise (e.g. What is the physics involved in a burglar alarm? What is the chemistry involved in batteries or fuel cells? How is sound created for a movie film? How does the detector in the light meter of a camera work?);
5) Science or computer applications and public policy issues;
6) Science or computer applications and social issues;

Note: Each paper must not only address the above topics, but also discuss some aspect of sustainability.

The purpose of having students prepare an abstract was threefold. First, the preparation of an abstract gave students a sense for how the abstract submission process is handled for a professional conference. Second, it provided students the incentive to choose a topic for their papers early and to

begin to focus on the research aspects of the project. Third, it was obvious that many students had never been asked to prepare an abstract before. Many students were challenged to effectively summarize a paper they have not yet written into a 150 word abstract. Thus, this task required the students to think within the "big picture".

To manage the process, the 380 students were paired with another student with common interests. This reduced the number of abstracts to 190.

All abstracts were submitted to a web-based electronic format. The electronic submission of abstracts encouraged professionalism from the outset of the paper preparation process and facilitated a more efficient and effective review.

Preparing the Sessions

Once the submission process was completed, all the student abstracts were reviewed by the course instructors and organized into common theme sessions. The abstract review allowed the instructors to prepare a preliminary conference schedule and to make sure the paper topics were consistent with the call for papers. Some students were asked to revise their abstracts because their initial topics did not parallel the conference theme closely enough.

The final conference will have approximately 30 sessions with approximately 6 papers presented per session. Because of the large number of papers to be presented it is not possible for one person to perform all the associated review tasks. To address this issue, 30 alumni volunteers from the Pittsburgh area together with 30 faculty volunteers were solicited to act as co-chairs for each session. Each session was co-chaired by one alumni and one faculty volunteer. These individuals also served as reviewers for the papers to be presented in their sessions. Over the past 3 years, the conference has had the following sessions topics:

> Chemistry Issues, Computer Issues, Bio-Engineering Issues, Mechanical Issues, Environmental Issues, Energy Sources, Transportation Issues, Military Issues, Physics/Civil Issues, Communication Issues, Medical Issues, Structural Issues, Electrical Issues, Industry Concerns, Future Issues, Manufacturing Issues, New Millennium Issues, and Aviation Issues.

A review of the session titles shows that the conference theme of sustainability has reached well beyond the classic "green construction" or "green engineering" definition used by many people. Thus, the goal of raising the awareness of sustainability has been achieved.

Preparing and Submitting a Formal Paper for Review

When students initially received notification that their abstracts had been accepted, they were given a copy of the formatting guidelines to be followed as they prepared their papers. The guidelines that were given to the students were essentially the same guidelines given to authors submitting a paper to the ASEE Frontiers in Education Conference. The paper submission process was a web-based format.

Receiving Reviewers' Feedback

All students' papers were subjected to a formal review process. To facilitate this process, each of the 180 teams of student authors met weekly with to give a short progress report. During the first year of the program, this meeting was with a team of TAs whose assignment was to supervise the students. In the second and third year of this conference, this task has been transferred to the undergraduate mentors. Thus, the success of the involvement of the mentors during the first semester, has resulted in expanding their involvement into the spring semester.

During these meetings students must demonstrate completion of various milestones set by the faculty. For example, during one weekly meeting students were required to submit an extended 2-page outline of their papers, during another they were required to submit a copy of the articles they were using for their papers, and during another they were required to submit short summaries of each of the articles they had collected thus far. Table 1 lists a summary of the various activities for each week.

The paper review was a multi-step process. After the abstracts were submitted, the ENGR0012 faculty initially reviewed the abstracts to establish the 30 sessions. Students were then required to submit an extended outline of their papers. This outline was posted on the conference web site so the session co-chairs could review the abstract and outline. The session chairs then met with their students to discuss the paper outlines. After this meeting students prepared the draft version of their papers and submitted it electronically, the week before spring break. The co-chairs were responsible for reviewing these submissions for technical content. A second meeting with the students to discuss the reviewers' comments was then held. In addition to being reviewed by the co-chairs, each paper was also reviewed by a faculty member in the English department. The reviews conducted by the English faculty members focused on writing style, form, and grammar.

An additional peer review process was also part of the process. The usefulness of this approach has been widely documented [41, 42]. Thus, in both courses, every student was assigned another student's paper to review. Since the students were paired in teams to write the papers, and each student did their own review, each paper actually received two student revfiews.

In summary, this process produced 5 independent reviews, one from the English department, one from an alumni, one from a faculty member and two from students.

Table 1 List of weekly activities in review process

Week of	Assignment	Comments
08-Jan	No Meeting	
16-Jan	- Choose partner for project	
22-Jan	- Turn in preliminary topic	**Purpose** --- To get the students to begin to research their topics and read the articles
29-Jan	- Bring in 3 articles on topic - Explain 1 randomly picked article - Explain their topic a little and what they want to explain in their paper	**Purpose** --- (1) To have students continue to research their topics and read the articles (2) To get students to relate sustainability issues to their chosen topics
05-Feb	- Bring in 3 articles on topic (2 from mag/journal) - Explain 1 randomly picked article - Identify 3 sustainability issues and explain how they relate to the student's chosen topic	**Purpose** --- (1) To get students thinking @ how they will write their paper. (2) To get students actually writing parts of their papers
12-Feb	No Meeting Students are meeting with their session chairmen	
19-Feb	- Bring in copy of outline - Talk to the outline and discuss what they want to discuss in their papers - Bring in 1 page typed paper about some topic in their outline	**Purpose** --- (1) To continue to have students actually writing parts of their papers. (2) To get students writing their bibliography and procure additional sources if required
26-Feb	- Continue to talk to their outline - Bring in copy of bibliography - Bring in 1 page typed paper about some other topic in their outline	**Purpose** --- Explain peer review process
05-Mar	Spring Break	
12-Mar	No Meeting Students are meeting with their session chairmen	
19-Mar	- Bring in peer review papers - Explain peer review process (meeting chairman)	**Purpose** --- To get the students thinking about their presentation and to start putting it together
26-Mar	- Bring in preliminary outline for presentation and discuss what points the student wants to make	**Purpose** --- (1) To get the students to prepare their presentation for the conference. (2) To go over the presentation and make corrections/ suggestions
03-Apr	- Bring in charts the student wants to present to the conference or a hard copy of their power point presentation - Talk to the charts/hard copy.	

THE CONFERENCE

Students utilized the reviewers' comments to prepare final copies of their papers. Typical papers ranged in length from 5 – 8 formatted pages. Because of the magnitude of the conference, the conference proceedings was only available on line, however, a matrix was created and distributed at the conference.

The students prepared and made use of overhead transparencies, PowerPoint slides, and demonstrations during their presentations. Students were also asked to wear appropriate attire for the conference.

Students were given 15 minutes for their presentations and then allowed two minutes for questions. It was not

possible to hold the conference during regular class time because of the sheer size of the conference. Thus, the conference was held from 8 am to 4 pm on Saturday, with lunch being provided.

The following section highlights student impressions regarding their overall experiences during the paper preparation process. In addition, feedback received during Phase I from students via a written questionnaire is summarized.

RESULTS

In the first year we were able to design the basic concept of the writing and library integration into the freshman curriculum. As faculty and staff we learned a lot about what could and could not be expected from the students, how to introduce the material, how to grade the student presentations, what type of handouts and grading keys were required, what could be expected from the mentors, and all the various logistic concerns. Thus, the main results we obtained during the first year were administrative issues. We also discovered that the content in the two - zero credit seminar courses had to be totally redesigned. Thus, in the second year we moved the department presentations from the Spring semester to the Fall, we added open house presentations into the Spring semester, and we extended the peer mentoring to the second semester ENGR0082 course. In addition, we added an intensive one week mentor training program to the week before school started. In this training we exposed the mentors to training in the areas of advising, diversity, communication skills, and mentoring skills.

The results from the Fall semester of the second year supported the changes we made as the students' acceptance of the project was much more positive than the first year. Based on the feedback from the students during their spring semester registration period at the end of the Fall semester, the project meet the advising concern, since the vast majority of the students stated the project made self evaluate their choice of major. The students either found that by researching their fields and talking to fellow students in their mentoring class they were questioning their choice and wanted to learn more about all the fields of engineering, or were now convinced the field they selected was the correct field for them. This is a very important result. One of the largest problems faced by advising centers is students changing their major after they have been taking classes for 2 - 3 semesters. Thus, by having the students research the concept of sustainability, we are finding that the students are also doing the same career exploration in the first semester of the freshman year, that typically takes place during their third of fourth semester. This has the potential of saving the student a large amount of time and money.

It was also clear that for the project to be successful, you must have the assignment well organized with handouts that can walk the students through the process. You cannot assume that a freshman knows how to write a report, this was the biggest error we made in the pilot.

By the end of the semester a number of goals were reached with the first writing assignment. First the students were exposed to the library and how to conduct a research paper. Second the students were exposed to the actual skills required to write a formal paper and give an oral presentation on an engineering topic. The last and most important concept was the students researched an area of engineering that they thought was interesting, and during this process they discovered a product or topic that dealt with sustainability in that profession. Thus, by writing the fall semester paper they discovered a topic for their second semester paper.

During the Fall of the second year we also starting getting feedback from the faculty teaching the Second year courses in the various departments. As one faculty member stated he was "blown away by the quality of the writing of his students compared to previous years". This also confirms the finding of the English department when they stated that the quality of the final papers was equivalent to the results that could be expected from taking a 3 credit writing course. Thus, the goal of improved writing skills was also meet by the project. It is clear that the main reason the writing skills of our undergraduates is so poor is because they do not know how to use the library to write a research paper, and the results we are getting this year support the concept that if you teach them how to do it they will improve their skills.

FEEDBACK FROM STUDENTS

Near the beginning of each semester, the students were quite apprehensive about the prospect of preparing a formal written paper. None had ever been given a writing assignment of this magnitude before. Although the students had done some writing when they were enrolled in the foundation course, ENGR0011, the task facing them seemed quite daunting. In addition, many students expressed anxiety regarding the fact that they were also being asked to present their papers orally. Comments from students suggested that they felt they would never be able to fill the 10-minute time period allotted them for their presentations. In reality, once students had completed their written papers and had prepared their materials for presentation, most found that they had too much material to fill the 10-minute time slot! Thus, the real challenge faced by most students was the condensation of their papers into a 10-minute presentation. Each and every student author was, however, successfully able to present their papers within the given time period.

On a questionnaire given students last year, students were asked to describe their overall impressions regarding the conference paper assignment. Typical student responses included:

- *I've never written a technical paper like that before. The topic was much more involved - and required you to really understand what you were writing about.*
- *I thought this was a difficult assignment that taught me a lot and was worth doing. It was a lot of work, but after doing it, I felt like I learned a lot. I never had to write a technical paper before and I'm happy that I can now say that I wrote a conference paper.*
- *I learned a lot about a subject that I would not otherwise have learned about. I had never written one of this magnitude, or that required so much in-depth research. We were allowed to pick the topic - which was nice.*
- *I have never written any form of technical paper at all. At first, I was not very excited about the idea of writing such a paper, but I did feel that I had a very valuable experience. I feel that I have learned so much - beyond physics principles. I also appreciated you forcing us to do rough drafts, so I was able to pace myself and put more effort into it than I otherwise would have.*

The following questions to sustainability were also part of the survey:

- How did the conference activities (research, paper, presentation) help teach the concept of sustainability as it relates to Engineering?
- Was the concept of sustainability adequately explained in the Freshman Seminar?
- Did the TAs do an effective job explaining the concept of sustainability in the weekly meetings overall and how it related to your topics?

On a scale of 1 - 5, with 5 high, the students responded an average of 3.5 on each of these topics. Thus, they found the paper did indeed help introduce them to the concept of sustainability. We also pre and post tested them on their views of what requirements engineers have should have related to issues involving social responsibilities and ethical concerns. On each item the difference between the pre and post scores was on the average of 20%. Thus, the students are developing an understanding on the need to consider the environment and society when they make their engineering decisions.

On the short answer survey questions the general response was they did not know anything about sustainability before the activity or they thought it was just an environmental engineering concern. Thus, with this rather simple task we were able to introduce all engineering students to the concept of sustainability and got them thinking about how sustainability could be included in all engineering projects.

The most interesting result, however, is not during the freshman year, but after they have completed a Co-op or intern work assignment during their second or third years. We continue to survey the students after each of their years at the university, and each year we ask them to evaluate their freshman experience. What we are finding is when you ask a second or third year student the same survey questions, the scores on the questions continue to increase with each year. We are finding that freshman do not truly understand the value of the conference experience, however, once they experience an opportunity to spend time in the work force they are being asked to consider many of the same topics we discussed in the freshman sustainability conference. Thus, the conference is introducing them to a topic that was never discussed in the past, and is preparing them for issues in the work force that deal with society, and sustainability.

SUMMARY AND CONCLUSIONS

All aspects of the conferences, from submission of an abstract to the formal submission of a camera-ready copy of their paper for publication and presentation, allowed students the opportunity to link the active process of writing to sound, scientific content. In addition, these activities allowed students to demonstrate their understanding of a topic or set of topics using their individual learning styles. This activity also provided the instructors with an additional assessment tool outside of the limits of more traditional assessment measures.

At the conclusion of the conference, it was clear that the students felt that all of the time, energy, and hard work they had devoted to the preparation for the conference had paid off. Many expressed that they had experienced a fairly steep learning curve on both the content covered as well as the rules and regulations they were required to follow as they prepared their formal papers. In addition, many students expressed gratitude for the opportunity they were provided to participate in such a formal and professional activity.

The underlying premise is that all students, no matter what their gender, cultural, or demographic backgrounds, can learn! In a recent report on its review of undergraduate education, the Advisory Committee to the National Science Foundation's Directorate for Education and Human Resources concluded that "… while K – 12 programming can expand the pool of those interested in pursing careers in SME&T [Science, Mathematics, Engineering, & Technology], it is at the undergraduate level where attrition and burnout can be most effectively prevented. What we in SME&T education must do is to concern ourselves with *all* students, not just those who historically have been represented in science, mathematics, engineering, and technology. Such a breadth of concern has important educational benefits as well, as it will force us to think more about how individuals learn and recognize what research has made clear: that there are differences in learning style which profoundly effect achievement. And let us not forget that increasing student achievement in SME&T education is exactly what is needed [43]" (p. 28).

Writing has proven to be an effective way to assist students in articulating their thoughts. In addition, the

opportunity to research and then write about a topic of personal interest can allow students a chance to demonstrate their understanding in a way traditional assessment measures do not permit. Hence, the application of a writing component into a course has enormous potential within both science and engineering communities.

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