Participation of Experienced Students in Introducing Freshman Students to Engineering Experimentation

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Abstract

Experimental measurements and data analysis are a key component of the suite of skills that all engineering students must acquire during their undergraduate studies. However, traditional curricula steer engineering students first to labs in the basic sciences such as physics and chemistry. Engineering labs are not introduced until the sophomore year; sometimes, even later. In this paper, the authors describe a novel collaborative effort between freshmen students and more-experienced students (sophomore, senior and graduate students), in developing an experiment of relevance to industry and commerce. The experienced students collaborated in developing the test apparatus and test procedures. Then they mentored the freshmen in conducting the test, collecting data, analyzing the results and generating recommendations.

The objective of this experiment was to measure the greatest height from which aluminum beverage cans may be dropped without appreciable damage to the can structure. The project was divided into different tasks, and the tasks distributed to three classes in various engineering curriculums. Tasks were assigned based on course emphases; to allow students to apply their course work. One class graphically designed the testing system. The second class manufactured the testing system and provided a prototype. The freshman class was assigned the task of testing the cans and analyzing the results. It provided for a vertically integrated learning experience, where experienced students were able to demonstrate to less-experienced students on how their use of the tools and skills has progressively grown more sophisticated.

Rationale

The concept of vertical integration relates to streamlining an entire curriculum so that there is a tangible connection between pre-requisite and follow-on courses. This has been achieved at many schools by cooperative planning between faculty members. This idea of vertical integration has been extended in the Mechanical Engineering curriculum at North Carolina A&T State University (Pai et al., 1997) to include concepts of mentoring and cooperative learning. Past research (Dale, 1969) has proven the efficacy of active learning, where the students experience a simulation of the real thing. Felder (1992), and Felder and Brent (1996) provide insight into the structuring of team activities and student-centered teaching. Evans et al., (1996), have applied the team-learning approach for an applied physics freshman curriculum with the use of team-based lab exercises. McDonald et al., (1996), have demonstrated the receptiveness of senior level students to industry-generated senior-level design courses. Mahajan and McDonald (1997) have developed an integrated laboratory sequence. In this paper, we are attempting to demonstrate how we have synthesized these excellent concepts into a hands-on experience of value to the entering freshman students. The rest of this paper discusses our approach to this problem, the implementation of our approach, and student feedback and perceptions of our efforts to date.

Approach

An industry-sponsored course entitled "Aluminum-Based Product Design and Manufacture" has been offered to senior level undergraduates and entering graduate students at this University since 1994 (Pai, 1996). The course features active participation by engineers from industry and features open-ended design projects. Part of the learning process involves a consideration of the use of aluminum sheet in the beverage can industry. We decided to get the seniors and graduate students involved in sharing some of their knowledge and experiences with freshmen and sophomore students through the use of the aluminum beverage can-drop experiment, described in the next section. The results to date have been positive, indicating an interest on the upper level students' part to improve their communications skills, and on the lower level students' part to acquire a first-rate grasp of the skills that will ensure their success in the profession.

Implementation

Introduction to Engineering Module

The GEEN 100 Introduction to Engineering course is required for all freshmen engineering students at NC A&T State University. It introduces future engineers to the various disciplines of engineering, the fundamental concepts of engineering design, representation of technical data and theoretical concepts that will be useful in their chosen course of study.

This project allowed students to use the theory discussed in the classroom to develop conclusions surrounding a practical issue faced by the nation's aluminum can manufacturers. This experiment attempts to bridge the gap between the classroom and the industry and opens new minds to understanding the physical and economical principles that govern our designs.
The students were given an identification statement that outlined the problem: *The average gauge (thickness) and weight of aluminum beverage cans have reduced over the years - for reasons of economy as well as efficiency in transportation and handling. The challenge has been to maintain the drop performance of the cans. One critical defect observed when cans are dropped is dome reversal. This is the bulging out of the (normally inward bulging) dome on the can bottom. It creates problems in can stacking and the aesthetics are not pleasing to the customer. While the beverage is not harmed, some customers even have concerns about spoilage of the contents when they see a reversed dome. Bulging is therefore a problem for beverage manufacturers. It is a significant problem because the 5 major US can manufacturers make a total of 100 billion cans a year. Even a small fraction of defective cans can add up to a lot of money! They have developed specifications for acceptable drop heights - i.e. heights from which the product can be safely dropped with no dome reversal. In this exercise, your team will perform an experimental, factorial study to determine the effect of the level of carbonation and nature of drop surface on the safe drop height.*

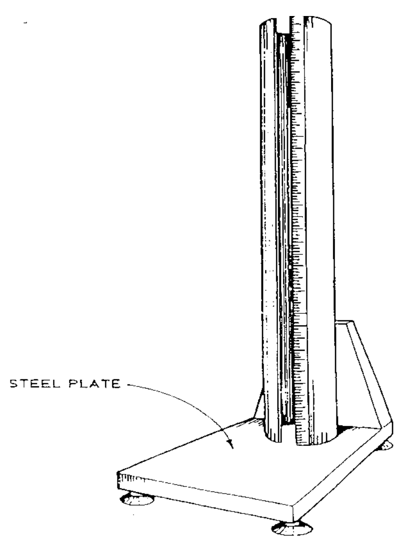

Figure 1 Existing Drop-Can Test

Working in teams, the students were then asked to evaluate the information given and develop a problem statement while researching the problem at hand. Doing so allowed the teams to exercise skills in problem analysis and enhanced their understanding of the procedures that would be used. The teams were asked to design tabulation sheets to be used in collecting experimental data before the experiment would begin. This would require each team to consider the experiment and the type of data that would be collected as well as a format that would be conducive to the pace of the experiment.

The students worked with two cases each of a carbonated (a cola) and a non-carbonated beverage (iced tea). During the course of the experiment, teams recorded pertinent data and observations. The observations were helpful in developing conclusions and understanding any discrepancies that occurred in the data. A final report was required of each team. In the report, students included sketches of failures, descriptions of observations and procedures, and tabulations and graphs of failure data with supporting statistical calculations.

Engineering Drawing Module

The GEEN 101 class – Introduction to Engineering Graphics, handled this module. In this class, students are taught to be able to document their ideas and solutions to engineering problems in a graphical form. The students use fundamental principles of engineering graphics to produce their solution. The final solutions are produced by hand sketches or computer graphics.

The GEEN 101 looked at the existing testing system (Figure 1) and brainstormed the redesign or development of a new can drop system. The class was given one week to complete the project. Students were given a handout explaining the project and given a chance to ask questions. A lecture was given on the design process. The class observed and interacted with other classes (GEEN 100 and MEEN 300) that were given other tasks in this project (For example, the GEEN 100 class was responsible for operating the test device and the recording the beverage can drop height and damage data. The students in the intro course also worked with the graduate students in doing their test. The class was shown a picture of the existing device. The class was divided into five groups with each group charged with working on brainstorming and developing their best ideas. Each group made an oral presentation. Each student wrote a project summary.

Many students decided to change the drop device from a hollow tube to an arm that the can could be dropped. Some groups decided to change the standards of the test and look at a device that would flip the can rather than dropping it straight down on the dome at the bottom of the can. Most of the presentation drawings were hand sketches instead of computer drawings owing to time limitations. Most of the students thought the project was worth while.

Mechanical Engineering Lab I Module

First-semester Mechanical Engineering sophomores take this class (MEEN 300). Students gain hands-on experience in the use of measuring instruments, lathes, milling machines, drill presses, shears, spot welders and other typical shop equipment, as well as a grounding in the principles of error and uncertainty in measurements, as well as in writing coherent and quality reports. These students were offered the opportunity of sharing their newly learned skills with entering freshmen in the GEEN 100 and 101 classes. The class of nine students worked in three equal-sized groups to brainstorm, optimize and produce three different can-drop apparati. They presented their designs and prototypes to the freshmen. Graduate students were involved in the brainstorming process as the sophomores built up their ideas.

Student Response

Students generally commented on the benefits and the limitations of interaction with the upper class. Their responses to specific questions are shown in Figures 2-4. Typical comments are:

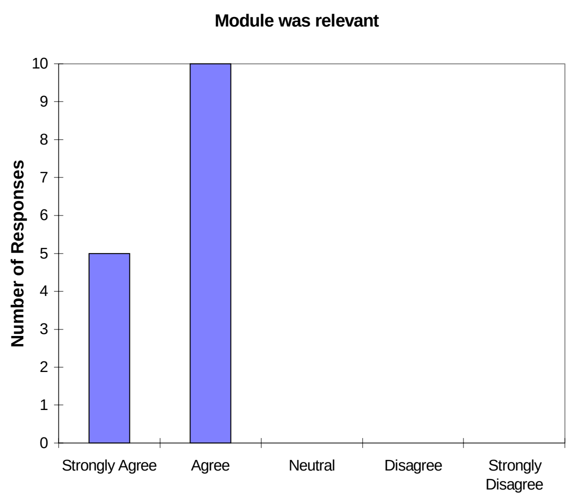

Figure 2 Relevance of Module

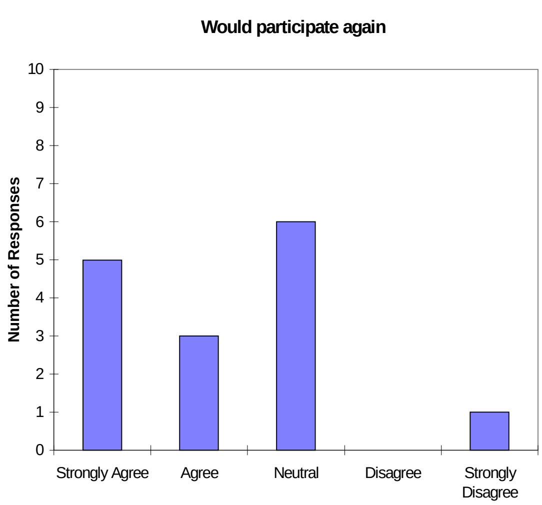

Figure 3 Willingness to Participate Again

Benefits:

- The project taught us how to brainstorm
- How to work in-groups.
- How to do better research.
- How to develop an idea.
- How the engineering design process works
- How to develop alternatives to a project.
- How devices that may work in theory may not work in reality.
- How the number of outside variables may affect a project.
- Got an idea of what to expect in advanced engineering classes
- Application of course work made understanding of topics clear
- Upperclassman were easy to relate too
- Better understand what not to do
- Acquired an idea of the quality of work required in advanced classes
- Liked the substantial content of the presentation
- Presenters gave good answers
- Presenters show teamwork and good participation
- Project model was high quality
- Presentation was well thought out
- Group was very familiar with what was being presented

Limitations

- Time constraints – should allow more time
- Students seem to have less knowledge than professors do
- Should have been in the beginning of the semester – came at the end of semester

Conclusions

We have developed a mechanism for upper class students and graduate students to get involved in the education of freshmen. The upper class students have been challenged to present an

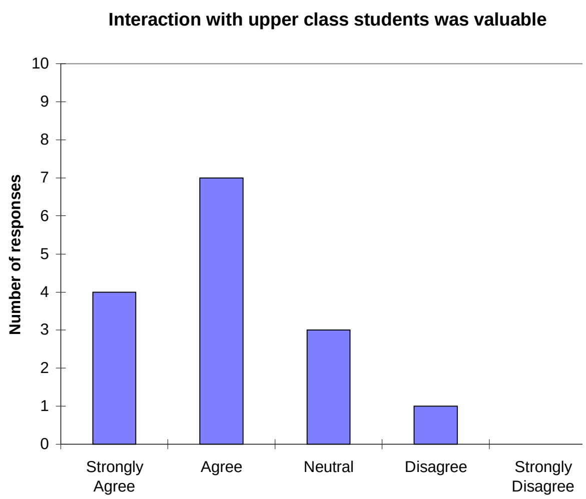

Figure 4 Value of Interaction with Experienced Students

industrially-relevant problem in terms that will capture and hold the interest of freshmen, as well as require the freshmen to plan an experiment, measure and analyze data, and present conclusions orally and in writing. The results to date are positive, indicating an interest on the upper level students' part to improve their communications skills, and on the lower level students' part to acquire a first-rate grasp of the skills that will ensure their success in the engineering profession.

Acknowledgments

Devdas Pai gratefully acknowledges the support of Alcoa; both for the funding that enabled the creation of a senior-graduate level course on Aluminum Product Design and Manufacture at North Carolina A&T State University, and for the valuable technical input of many Alcoa employees, including co-author Richard DeBlasio.

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