Results of Using Multimedia Case Studies and Open-ended Hands-on Design Projects in an 'Introduction to Engineering' Course at Hampton University[1]

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Abstract

This paper describes the implementation of a revised freshman engineering course, "Introduction to Engineering," at Hampton University and the observations of the instructors during its implementation. The authors collaborated with Auburn University faculty in jointly implementing the same course material at both universities. The revised course used multimedia case studies and open-ended hands-on design projects to improve student learning outcomes and retention of engineering students. The paper describes the implementation of the revised course and gives some observations of the instructors. One finding was that the best student presentation discussions occurred during the multimedia case studies. Hampton University students felt all three case studies were mainly about engineering ethics. The other topics involved in the case studies, such as design, safety, and statistics, were not perceived in the same way as ethics. A second observation was that the students at Hampton University were highly motivated by the open-ended hands-on design projects.

Introduction

Instructors always have a dilemma. "I teach a topic, but it does not mean students learn the topic." Instruction does not automatically mean learning (Vermunt,1996; Schilling et al., 2003). Research has indicated that compared to traditional instructional methods, multimedia instructional methods including photos, animations, video, etc., encourage more student participation and more active involvement in learning (Mbarika et al., 2003; Durodoye et al. 1995). This pedagogy may be particularly effective for African-American students who prefer interactive environments and whose general learning style might be categorized as "learning by doing" and visual learning.

Since 2007, the faculty of the School of Engineering and Technology at Hampton University (HU), a Historically Black College or University (HBCU), has identified a need to revise the engineering curricula to better prepare engineering students for the innovation age. Students now must be able to solve open-ended problems and acquire higher-order cognitive and teamwork skills. Starting with the freshman course "Introduction to Engineering," engineering faculty at Hampton University are investigating ways in which traditional course content can be taught using multimedia case studies and open-ended hands-on design projects to facilitate learning. The faculty is also investigating whether revising the curricula will improve the image and understanding of engineering as a career. Increasing student awareness of engineering should attract more students to the study of engineering disciplines, and increase the retention of engineering students. Supported by a National Science Foundation (NSF) grant EEC#0934760, Hampton University is currently collaborating with Auburn University to develop and test a Presage-Pedagogy-Process-Product model to assess the effectiveness of a multimedia case study methodology to improve student learning outcomes.

EGR 101/ Introduction to Engineering

Each semester at Hampton University, EGR 101: Introduction to Engineering is offered to freshman students from the School of Engineering and Technology, the School of Business, and Music Recording Technology.

After taking this course, students should be able to:

1. Understand the role of the engineering profession in society and the engineering disciplines.
2. Identify a problem and mathematically formulate it.
3. Function as a member of a multidisciplinary team.
4. Understand professional and ethical responsibilities.
5. Communicate effectively.
6. Recognize the need for and have the ability to engage in life-long learning.
7. Use engineering techniques, skills, and tools necessary to practice engineering.

The course content traditionally addresses the disciplines of engineering, engineering ethics, fundamentals of units and unit conversion, data representation and graphing, statistics, engineering design, and problem solving in a lecture format. Course content is typically taught by the instructor using a question and answer format with the blackboard/whiteboard and/or using an electronic presentation to enhance the explanation and with examples to clarify the students' understanding.

A typical student project is to have students work in teams to make an oral PowerPoint presentation (as a team) to the class about a

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chapter or section from the textbook. In another project, students go to the library and receive instruction about how to conduct a literature search by accessing online engineering and science databases rather than a typical online search. Sudents then write a short report on the literature search process that is also intended to provide an opportunity to practice their written communication skills.

A class section usually consists of 25 to 30 freshmen of whom approximately two thirds are business majors, one third engineering majors, and two or three music majors. The course serves as the first engineering course for engineering majors. Therefore, it needs to be stimulating and engage engineering students, informing them about how exciting an engineering career can be. It also should provide students with interesting engineering activities.

Implementation of the Revised EGR 101– Spring 2010

Starting in the spring semester of 2010, two sections of Introduction to Engineering (EGR 101) were taught in collaboration with Auburn University. Both Hampton and Auburn Universities used the same textbook (*Fundamental Leadership and Engineering Competencies*, by Raju, Sankar, and Le 2010), projects, homework, exams, case studies and grading policy. The first class section, EGR101-01, had 15 students and the second class section, EGR101-02, had 10 students.

At the beginning of the semester, students were surveyed to determine their learning styles using the Index of Learning Styles Questionnaire (ILS) given in http://www.engr.ncsu.edu/learningstyles/ilsweb.html. The learning style survey showed that most Hampton University students were visual learners. Accordingly, in later lectures, instructors paid more attention to the visual content and impact of the lectures by including more pictures and videos.

The class content may broadly be classified into the three following categories:

1. **Open-ended, hands-on engineering design projects**
2. **Lectures on engineering fundamentals**
3. **Engineering case studies**

After learning the basic concepts of engineering design, students were assigned two hands-on design projects which were to build a paper parachute and a pasta tower. For the paper parachute project, students were divided into four teams to develop a parachute design. Each team had at least one engineering student so the team would be multidisciplinary. Students were limited in the amount of materials they could use for their design. During the first 30 minutes of class, students were able to experiment with different design ideas and decide on a final design. In the second part of the class, each team's design was tested by the instructor. Each team was asked to write a report about their design choices and experiences and present these in the following class.

Paper Parachute Project – Each team was given four sheets of 21.6 x 27.9 cm paper, a pair of scissors and a roll of 12.7 mm wide scotch tape. They were asked to design and build a paper parachute using only the materials they were given. The amount of time it took for each team's parachute to come to a full stop on the floor when released from a height of 2.44 m was measured by the instructor. The objective was to design a parachute that would take the greatest amount of time to reach the floor and come to a stop. Students were told that while the word "parachute" was used as a description, the design process was open-ended, and any structure they could build that met the assignment objectives with the given materials was an acceptable design.

Pasta Tower Project – Each group was given a 16 oz box of spaghetti, a roll of 12.7 mm wide masking tape and a pair of scissors. They were asked to build a self-standing structure of any shape with height as its largest dimension and that was able to support as heavy a load as possible. The test criterion for the design was given as the product of the load and the square of the height. Figure 1 shows examples of pasta towers built by student teams.

Students found the projects very appealing. One said "the knowledge learned from Physics finally paid off."

Later classes introduced basic engineering fundamentals, engineering safety, and engineering ethics. Students received lectures on various subjects generally considered to be important in engineering practice, including mathematical tools used in most engineering disciplines. Students were given examples and asked to solve engineering problems using the mathematical tools they learned during the lectures. While a variety of mathematical methods used in engineering and science are presented in the course, the learning outcomes are not always clear. Students were also given examples of difficult ethical situations and safety issues. The lecture subjects included

Figure 1. A. A tower supporting a load of 5.7 kg.

Figure 1. B. A tower collapsing under a load of 13.6 kg

teamwork, oral and written communication, safety, ethics, data representation, statistics and unit conversion.

In the middle of the semester, three multimedia case studies—STL-51 Space Shuttle Challenger, Della Steam Plant, and Chick-fil-A—were presented to the class. These three case studies were carefully chosen by the research teams at both Auburn and Hampton universities to fit the course learning objectives. Specifically, the STL-51 Space Shuttle Challenger case study covers engineering design issues, engineering ethics, statistics, and the process of decision making. The Della Steam Plant case study discusses engineering ethics, safety standards, and machine design issues. The Chick-fil-A case study also covers the decision making process and operating systems that fit the learning objectives of the course.

Each case study was conducted in two one-hour classes. In the first class, the instructor used PowerPoint slides, prepared by the instructor, to briefly introduce the case study. Classes were divided into three student teams each composed of three or four students. Two of the teams were assigned to defend a different possible case study outcome while the other team was assigned the role of a jury. Each team served as a jury for one of the three case studies.

After the first class, students were supposed to have a broad understanding of what the case study was about. In the second class, one week later, the two student teams assigned to defend a possible case study outcome made 12-15 minute presentations to the class. The jury team then made a 3-5 minute summary presentation on their decision. The class was to ask questions as the teams made their presentations.

For example, in the Chick-fil-A case study, Mike Erbrick, Director of Restaurant Information Systems at Chick-fil-A, was given the responsibility of determining the restaurant's best point of sales (POS) system from a proprietary erasable programmable read-only memory (EPROM) based system or from two Microsoft Windows systems. The Chick-fil-A case study requires the students to use decision making in selecting a POS system based on one of two Microsoft Windows based systems, or using the current EPROM system. One team was assigned to defend the choice of a Windows based system. A second team was assigned to defend the choice of the current EPROM system. A successful team was expected to demonstrate the following characteristics: appropriate knowledge of operating systems, appropriate knowledge of the needs of the Chick-fil-A company, good communication skills and a strong teamwork spirit.

Observations of the Instructors

1. In the first case study (the Space Shuttle Challenger), students made relatively poor oral presentations in comparison to the case studies that followed. These presentations lacked adequate problem statements, approaches to a solution, and final conclusions. The reasons are not completely clear, but might be that students lacked experience in preparing and giving oral presentations, rather than a lack of interest in the topic.
2. In the second and third case studies, student performance improved. The students seemed more interested and enjoyed debating and challenging their classmates with hard questions. One said, "I wanted to see how this person reacted when a hard question was asked." Case studies have been used for the past three years and the best presentation discussions occurred in the spring semester of 2010 when multimedia case studies were used.
3. Students used a lot of examples and even their personal experiences in presentation discussions in the spring semester of 2010, which was quite impressive. For example, they used warming up a car in the winter to illustrate that the turbine must be fully warmed up for accurate measurements to be made in the Della Steam Plant case study.
4. All the students, particularly the engineering students, seemed to be highly motivated by the open-ended, hands-on design projects. There was less student enthusiasm for the engineering fundamentals lectures.
5. Students seemed to enjoy many portions of the case studies in the spring semester of 2010. The Chick-fil-A case study was the most popular, probably because the students were most familiar with the company, the product, and the technology discussed. Surprisingly, students did not have as much interest in the Space Shuttle Challenger case study as the instructor expected, probably because the students were very young or not even born when the case study events actually occurred.

Findings and Discussion

The 2010 spring semester was the first semester the two universities coordinated instruction and teaching materials for the course. Weekly one-hour teleconferences were conducted throughout the semester with Hampton and Auburn University team members. The teleconferences provided an excellent medium for coordinating the various course activities among the different sections at Hampton and Auburn Universities. Experiences and observations were exchanged between instructors at Hampton and Auburn Universities. The teleconferences facilitated making occasional course modifications as they became necessary during the semester. The teleconferences also provided a venue for sharing and discussing new ideas.

The combined team of faculty and researchers at Auburn and Hampton universities included individuals at different stages of their careers, including some graduate students. As a result, the weekly teleconferences also provided an opportunity for younger faculty members in the team to receive feedback and suggestions from more experienced senior faculty members. The team discussions during these teleconferences about different approaches to solving implementation problems and approaches to new ideas provided a routinely available mentoring resource to younger faculty. The availability of such mentoring was highly beneficial to the implementation of the revised course.

One finding at Hampton University was that students felt all three case studies they experienced were mainly about engineering ethics. The other topics involved in the case studies such as design and safety were not perceived in the same way as ethics was by the students. One reason for this perception may be that students understood and were able to relate to the ethical issues in the case studies more clearly than the other topics involved. How to present the case studies involving other engineering topics like engineering design, safety, and statistics is still a challenge to be solved in future semesters.

A second finding was that students at Hampton University were highly motivated by and engaged in the open-ended hands-on design projects. Students displayed good teamwork during the design phase of the projects and showed a competitive spirit among the teams as to who would be the winner. The students were less engaged in the lectures on engineering fundamentals.

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