Maintaining Quality and Student Enthusiasm in a Freshman Engineering Course

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Abstract

Freshmen frequently enter an engineering program with no clear idea of what engineering is about. Thus, most colleges require freshmen to take an introductory course in which students study aspects of all of the engineering disciplines. Union College is no exception, and over the past five years we have been working to develop an introduction to engineering and computer science as part of the freshman year. This introductory course presents information about Computer Science and Electrical, Civil, and Mechanical Engineering, in enough depth and with sufficient enthusiasm to help students choose an engineering major. In the past we have had faculty from each department teach a "module" featuring concepts from his/her particular engineering discipline. Students have complained that this format lacks cohesion and that they didn't have a chance to get to know any of the instructors. We have addressed this student concern by selecting a unifying theme, and having a single faculty member teach all of the components of the course.

Union admits about 125 freshman-engineering students each fall and that requires five faculty members to teach five section of the class. The problem we had to solve is how to ensure consistent quality for all of the course components in all of the course sections. For example, we need to ensure that an electrical engineering faculty member presents civil engineering concepts with the same level of competence and as much enthusiasm as a civil engineering faculty member would. The key elements we used in solving this problem at Union College are:

- Developing our lectures and then presenting them to the entire freshman-engineering faculty so that all faculty could feel comfortable presenting all of the course material.
- Selecting a unifying theme ("smart cars" this year) to provide connections among all the engineering and computer science disciplines.
- Encouraging students to contact the faculty team member from the appropriate department for more in depth answers.
- Working as a team to develop an attitude that the success of the course depends on its being well received by all course sections (no "star" faculty).

By working together to implement the course we serve as role models for our students. It is clear that cooperative team teaching contributes to the development of the same skills among our students. This paper describes the cooperative and team teaching we used in our freshman-engineering course this past fall

I. Introduction

Five years ago Union College implemented a first-term freshman engineering program designed to provide an introduction to engineering to incoming freshman engineering students. In response to student and faculty evaluation this program has changed in many ways since its creation. The faculty who taught the course this past fall have prepared a paper describing the details of the course as it was presented [1]. However, this paper concentrates on the cooperative teaching aspect of the course. In the past we have had faculty from each department teach a "module" featuring concepts from his/her particular engineering discipline. Students have complained that this format lacks cohesion and that they didn't have a chance to get to know any of the instructors and thus didn't know where to go to get help. In addition, our Dean For Undergraduate Education (Kimmo Rosenthal) expressed a concern that students (especially freshmen) do not receive appropriate advising. In order to improve freshman advising Dean Rosenthal is assigning faculty to be freshman advisors who have the student in a class as well as being a member of the department representing the student's chosen major. Thus, the faculty advisor sees the student on a regular basis and can mediate problems as they occur. Implementing Dean Rosenthal's program for freshman-engineering students requires having a single instructor for the entire course. The major impediment to implementing the single instructor course has been that many faculty feel that it is not possible for an instructor to teach adequately a subject outside his/her specialty. In this paper I describe the steps we took to ensure that the students in all sections of the course were presented with the same high quality presentation. Finally, I use the final exam given to students at the end of the course, as well as anecdotal information, to evaluate the effectiveness of our efforts.

II. Course description

In the first two weeks of the course students look at some of the engineering careers involving each of the engineering disciplines taught at Union College (Electrical Engineering, Mechanical Engineering, Civil Engineering, Computer Science, and Computer Systems). A recurring theme in all of the engineering careers studied is that of problem solving. Students prefer to study concepts in the context of a practical application. For this reason, part of the course is a "Design Studio" in which students learn about engineering principles by applying these principles to solving the problem of implementing a machine to dump ping-pong balls into a basketball hoop. To add interest to the project students compete by pitting their machine against other students' machines to see who can place the most balls in the hoop in the shortest time. The problem-solving theme is also used to connect the "Design Studio" to the lectures. The concepts presented in the lectures are connected using a "Smart Car " theme, which also involves problem solving. For example: the problem of increasing gas mileage, decreasing pollution, and improving drivability in an automobile is an important contemporary issue. To understand the problem and the possible solutions, energy, fuels, combustion, air/fuel ratio, and the Otto cycle are discussed in the cars and energy section of the lecture. In the cars and computing section of the lecture, students study how a computer-controlled feedback system can be used to control the air/fuel mixture in an automobile to provide maximum efficiency and performance under varying driving

conditions. This use of themes provides a framework for presenting an interesting and cohesive freshman course.

III. Implementation

The course was developed over the summer of 2000 by the faculty who were to teach the course in the fall. Each faculty member was given the task of developing the lectures relating to his/her field. Each of us then presented our lecture to the rest of the freshman-engineering faculty as if we were lecturing to a class. In this way we were able work together to develop clear interesting lectures that we could all present with equal skill. The classes were developed to include lectures using PowerPoint presentations (with note pages for the instructor), in-class examples, printed handouts, and homework assignments.

The fall 2000 freshmen engineering course was taught by faculty from the following departments: the section 1 and section 3 instructors were from the Electrical Engineering/Computer Science (EE/CS) department, the section 2 instructor was from the Civil Engineering (CE) department, and the section 4 and section 5 instructors were from the Mechanical Engineering (ME) department.

IV. Evaluation

For the course to be considered a success students must learn the engineering concepts equally well from all five of the instructors. In this paper I use the final exam and student feedback to evaluate our success.

A. Final exam.

While there are many factors that affect grades on exams, such as study skills, previous preparation, and motivation, I feel that the course final exam can give us an indication of the level of our success. The final exam is comprehensive and includes questions in the following categories: cars and energy (ME), the design studio (design and application), cars and computers (EE/CS), and infrastructure (CE). It is a multiple choice type exam and consists of two sections. The first part consists of 35 general concept questions worth 2 points each and the second part has 25 more difficult questions requiring the application of formulas and calculations worth 4 points each. While the exam does not have the same number of questions in each category, there are enough questions to give an indication of the any correlation between a students' ability to answer questions relating to a category and the field of expertise of the instructor.

A spreadsheet was used to analyze the final exam data for each student by section. Each student's exam results were entered with the result of each question in a separate cell. A 0 was entered for each incorrect answer, a 2 for each correct 2-point question, and a 4 for each correct 4-point question. Questions were classified as ME, EE/CS, or CE, and the total number of points correct for each category for each student was calculated. The average number of correct points for each category for each section was calculated as well as the average for all students in all sections for each category. The graph in Figure 1 below shows a plot of the percentage difference between the section averages and the average for all

students by category. Thus, each vertical column of five points represents the relative ability of the students in each section to answer questions relating to that topic. Sections taught by a professor from the relevant department are labeled “Expert”. From the graph it can be seen that there is no correlation between the expertise of the instructor and the ability to teach the concepts.

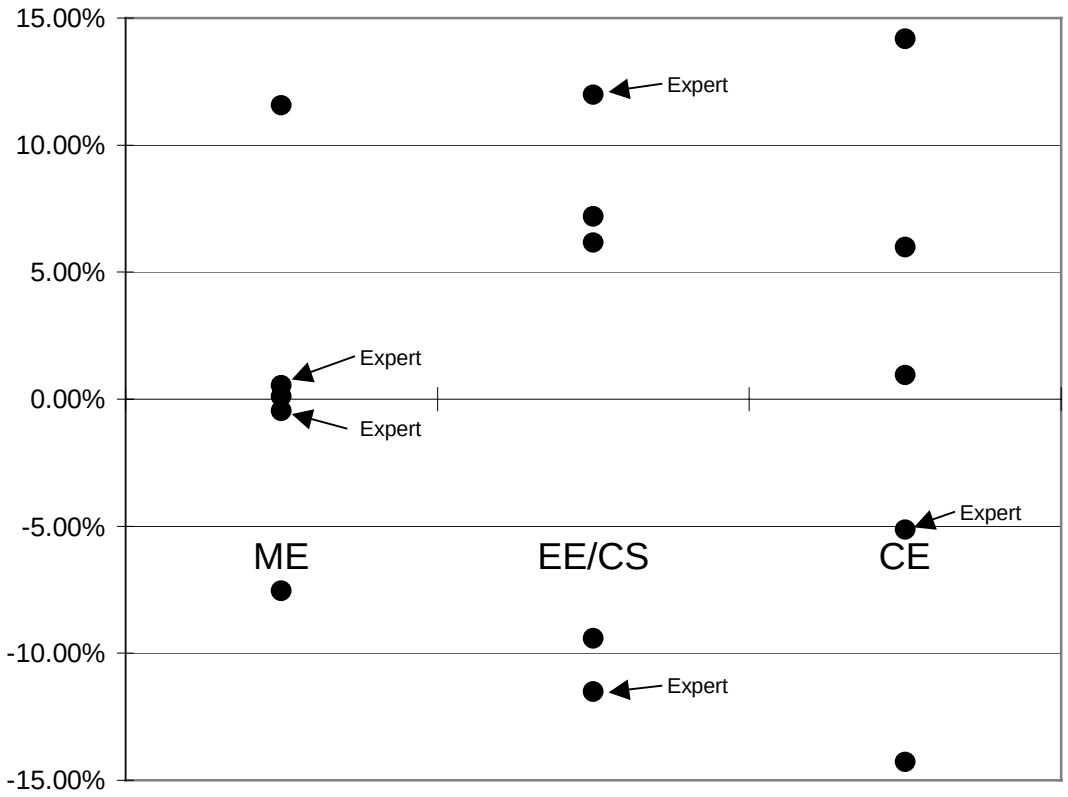

Fig 1. Percent difference between the average number of correct points by section and topic and the average for all students by topic.

B. Union College course evaluation

All Union College students fill out a course evaluation form for each course they take at the end of each term to provide feedback to faculty and the administration. The evaluation consists of two parts. The first part consists of questions that are answered by selecting a response from 1 to 5 that indicates to what extent a student agrees or disagrees with a given statement. The second part of the evaluation consists of open-ended questions relating to how students felt about the instructor and the presentation. This type of evaluation is difficult to interpret because, as first-term freshman, the students don’t have much with which to compare the course. Indeed, one student responded to the evaluation question asking students to discuss the difficulty and challenge of the course responded: “I’m not sure, I haven’t taken any others yet”. However there was some interesting information from the students’ responses to the open-ended questions in the evaluations. To get a sense of the tone of the free form answers given on the student evaluation forms, our Dean of Engineering, Robert Balmer, looked for a frequency count of words that would indicate a negative response and words that would indicate a positive response. The positive word count was as follows: “excellent” –3 times, “challenging” – 13 times, “very good”

– 8, “pretty good” – 2, “good” – 32, and “not too bad” –3; for a total of 61. The negative word count was as follows: “bad” –2, “boring” – 7, “poor” –3; for a total of 12.

C. Engineering survey

In addition to the standard Union College student evaluation form freshman-engineering students were asked to answer a survey with questions relating specifically to freshman engineering. For example, we wanted to know how well students felt we met course objectives. Course objectives are included in the syllabus that is given to students in printed form the first day of class and is also available on the freshman-engineering WEB site. The survey asks students to evaluate how well they feel the stated objectives were met and the table in Figure 2 below summarizes the students’ responses. It is interesting to note that an overwhelming number of students felt that all of the goals for the course were either met well or very well, and in particular the goal of teamwork skills, more than 90%.

Topic	As a result of this course I can now do this:			
1) Design concepts	Very Well	Well	Poorly	Not at All
(a) I am able to carry out the design of a simple system.	55%	41%	3%	1%
(b) I am able to identify and define the five basic steps in the design process.	41%	53%	6%	0%
(c) I understand basic manufacturing and project scheduling issues.	40%	53%	6%	2%
(d) I have developed a portfolio of design projects carried out during the course.	30%	43%	20%	8%
(e) I have developed an appreciation for the role of ethics in engineering decision making and design.	31%	53%	12%	3%
2) Teamwork concepts	Very Well	Well	Poorly	Not at All
(a) I can identify the skills required for good teamwork.	61%	33%	5%	2%
(b) I can identify the characteristics of good teams.	64%	32%	2%	2%
(c) I have completed exercises requiring a team effort.	60%	32%	8%	0%
3) Technical communication skills	Very Well	Well	Poorly	Not at All
(a) I can complete a sketch and a drawing of a simple system.	47%	48%	4%	1%
(b) I have prepared written reports on design work during the course.	54%	41%	5%	0%
(c) I have organized and delivered oral presentations of design work to a group of peers during the course.	45%	50%	4%	1%

Fig. 1. Tabulation of the student survey questions relating to stated objectives. The table is courtesy of Robert Balmer.

On the survey students were asked what major they were considering when they arrived at Union College in the fall and then what major they are considering now. Union College is a liberal arts

college with an engineering school and students have the ability to change their major from engineering to liberal arts and from liberal arts to engineering. In the past we have had a large number of students leave engineering to study liberal arts. The survey taken at the end of the course this fall indicates that 7 out of 101 students (6.9%) are considering switching from engineering to liberal arts. This shows a general satisfaction with the freshman-engineering course.

V. Conclusions

I feel strongly that the main reason for the success of our freshman-engineering program is the spirit of cooperation among the faculty both in preparing for and in implementing the course. Once the term began weekly meetings were held to discuss problems and to prepare for the next weeks lecture and design studio. However, cooperation was not limited to the formal meetings and all of us felt comfortable asking for and providing assistance at any time. Several times I asked colleagues for help in preparing for class (both lecture and design studio) hours before class started and have done the same for them. I have attended classes taught by colleagues in order to do a better job of presenting the same lecture to my own class and have had them attend my class for the same reason. All of us have suggested the name of a faculty team member from the appropriate department to a student when we were unable to give a complete response to a student's question. I feel that this cooperative teaching model was responsible in part for the students' perception that the goal of achieving teamwork skills had been overwhelmingly met. That is, students were able to observe faculty working together to present the freshman-engineering course.

The Union College Freshman Engineering Team for the Fall 2000 Term: Robert Balmer (Dean of Engineering - did not teach a section but acted as coordinator), Richard Wilk, Frank Wicks, Cherrice Traver, William Keat, and James Hedrick.

Bibliography

1. Wilk, Traver, LaPlant, Hedrick, Keat, & Wicks. 2001. A Freshman Engineering Course Which Introduces Engineering Design and Engineering Fundamentals in the Context of a Unifying Theme. ASEE 2001 Annual Conference Proceedings

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James Hedrick received a B.S. and M.S. in Electrical Engineering from Union College. He has taught both electrical engineering and computer science for the past five years in the EE/CS department at Union College. In addition to teaching, he has recently been appointed to the position of Associate Director of the Union College Academic Opportunity Program. He was one of the instructors who collaborated in the development and teaching of the Freshman Engineering this past fall (fall 2000).