A New Model for an Introductory, Multidisciplinary Freshman Engineering Course

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Abstract

Like many engineering schools, we are striving to find a solid prototype upon which to base a successful introductory, multidisciplinary engineering course. All freshmen in our engineering school are required to enroll in a two-credit orientation course. The course objectives are to provide an introduction to all School of Engineering and Applied Science (SEAS) disciplines, build a sense of community, introduce success strategies for college, acquaint students with the university, and lay a foundation of introductory discipline-specific topics upon which their curriculum will build. Our majors include computer science as well as various engineering disciplines. We, like other engineering schools, have struggled with the common challenges of frustrated faculty and bored students [1,2]. In the past, large entire-cohort lectures have proven unsatisfactory because a single topic does not hold the attention of students across the various majors. Additionally, the interaction between the presenter and the students is more restricted in a large group situation producing passive, rather than active learners. Our course has evolved into a variation of a hub and spoke model, and it has become a true multi-media experience.

1. Introduction

We have recently been struggling with our introductory engineering model, examining other models, and searching for the single course that will satisfy the needs of both faculty and students. We wanted our course to include the strengths of other engineering orientation courses such as community building, study and time management skills, and an introduction to the university and school [3,4]. At the same time we wanted it to emphasize design. The design problems that we included in previous versions of the course, such as designing the highest paper tower or the strongest weight bearing structure from specified material, were deemed to be too simplistic by the students. Even a major group design project of building a device to aid the disabled was less than successful, from the students' point of view. They wanted more complex and realistic projects. They also were impatient to obtain some "real engineering" experience rather than waiting until their sophomore year [5]. When one considers that engineering students are generally among the most capable due to stringent entrance requirements, it seems reasonable that they are able to handle more challenging course content. The result of our evaluation of the previous course model was a radical redesign of our course that included more hands-on, reality-based projects and discipline-specific instruction, including multiple media. We believe we have struck a balance between generic introductory material, community building, design, and material that introduces each student to his or her engineering area of interest.

2. Current Model

Our current course consists of several hub lectures that include all students, discipline specific spoke lectures that are held in four separate classrooms, and weekly labs. The hub and spoke lectures are held every Friday for 50 minutes. They are either preceded or followed by a two hour lab. Attendance is required at all lectures and labs. Facilities required to accomplish this include a large lecture hall, three other classrooms for the spoke lectures (the largest spoke meets in the lecture hall), and five classrooms for the labs. Our faculty and staff include four professors and five teaching assistants from the engineering school. The faculty and TAs represent of the main SEAS disciplines. We consider the instruction of this course to be a team effort that includes weekly meeting of professors and teaching assistants to discuss concerns and strategies, plan labs, and coordinate teaching assignments.

The hub lectures consist of topics that are of interest to all students and are usually presented by a guest lecturer who is an acknowledged expert in the field. The hub lectures this semester included an introduction to engineering, design, engineering ethics, basic statistics and deceptions, and a virtual reality lecture on virtual locomotion. Rather than duplicating efforts in individual spokes, we brought all students together for these topics.

The hub and spoke lectures, Table 1, are interspersed so that during the week following a hub lecture, there is follow-up material presented in the individual spokes and labs. In this way we have been able to present discipline-specific material, relevant to the various majors. For example, in the spoke lecture following the hub ethics lecture, the computer science spoke was presented case studies about disasters that occurred because of ethical dilemmas in handling bugs in computer software such as Therac-25 and the Pentium chip flaw. The engineering spokes examined the ethical dilemmas of engineers involved with such disasters as the Tacoma Narrows Bridge collapse and the Challenger Space Shuttle. The labs followed up by discussing topics closer to the students' realm of ethical concerns such as cheating, plagiarism, or doing less than one's fair share of the work on group projects.

In the past, all of our lectures were held in a single lecture hall with all students in attendance. Currently, only 5 of the 14 class meetings are held as large, group lectures. The remaining lectures and activities are held in labs and four discipline-specific spokes: computer science, civil and mechanical engineering, electrical and computer engineering, and systems engineering and undecided majors. Students are required to attend class weekly but are encouraged to attend whichever of the spokes they choose, based upon their interests and the topic being presented. The smaller spokes have created a more intimate classroom environment in which students and instructors can interact during lecture and discussions. Spoke lectures are taught by a professor and a teaching assistant. The spokes present the opportunity for students to become acquainted with peers in their major and receive discipline specific instruction, according to their major.

Labs and hub activities introduce students to those in other majors and present topics of general interest.

Week	Type	Lecture Topic
1	FT	Overnight Retreat and Ropes Course
2	H	Introduction to Engineering
3	S	Study Habits; Adjusting to College
4	S	Discipline Specific Topic 1
5	H	Design Guest Speaker
6	S	Discipline Specific Design Lecture
7	H	Ethics Guest Speaker
8	S	Discipline Specific Ethical Case Studies
9	FT	Submarine Field Trip to USS Pittsburgh
10	H	Using Statistics / Statistical Deceptions
11	H	Virtual Locomotion Guest Speaker
12	S	Discipline Specific Topic 2
13	S	Discipline Specific Topic 3
14	S	Discipline Specific Topic 4

Table 1. Spoke (S) and Hub (H) Lecture Topics and Field Trips (FT)

Two of the whole cohort activities included field trips. Our first class consisted of a retreat to a nearby camp. Activities included an introduction to engineering faculty and disciplines, a question and answer forum with current engineering students, a presentation by a graduate student submariner, a Ropes course for confidence and community building, a social hour, recreation time, common meals and dormitory sleeping quarters. In addition to the freshmen engineering students, SEAS professors, upperclass students, the dean, and course teaching staff all attended and participated in the retreat activities. The second field trip involved a bus and launch ride to tour a nuclear attack submarine to examine its various engineering systems.

Week	Lab Topics
1	Overnight Retreat and Ropes Course
2	Introduction to University / Scavenger Hunt
3	Web Page Computer Science Project Presentation
4	Study Skills; GPA Calculation; Spreadsheets
5	Computer Engineering Project Presentation
6	Design Exercises
7	Mechanical Engineering Project; AutoCAD Demo
8	Ethics Case Studies
9	Submarine Field Trip Computer Engineering Project
10	Data Analysis Exercises
11	Civil Engineering Project
12	Written Reports / Library Research
13	Systems Engineering Project; LINDO Demo
14	Coop Presentation; Wrap-up; Course Evaluation

Table 2. Laboratory Topics and Projects

Table 2 describes lab activities that are held for a two hour period on the same day as the lectures. There are five time slots to accommodate all student schedules. A student always attends the same lab section of no more than 30 students. The teaching assistants prepare the students for their six required projects, review material previously covered, present several new topics, lead discussions, and answer follow-up questions about homework and lab assignments.

In addition to re-emphasizing the hub and spoke lecture topics, project topics are presented during the labs. The projects represent each of the six majors of civil engineering, computer science, computer engineering, electrical engineering, mechanical engineering, and systems analysis. They comprise sixty percent of a student's grade. Each is designed to be a hands-on project where the student is required to use the tools of each particular discipline. This frequently involves a trip to a lab for a demonstration. The students have received instruction on and have been required to use HTML and UNIX, AutoCAD, LINDO, and spectrometers in the labs. One lab consisted of the submarine field trip. Lab projects are frequently completed in teams comprised of students with diverse majors. This allows a student to be somewhat of the "expert" in his or her group on one project and a novice on other projects.

3. Projects

The purpose of the Computer Science project is to give students the opportunity to "program" in a simple language. The assignment is an individual one. It involves obtaining a SEAS email account and web space, learning how to transfer files using ftp, creating an individual web page using HTML, and learning how to link to their advisor's web page. The latter has alleviated past problems of students not knowing who their advisor is or where they are located when registration for the next semester is imminent.

The purpose of the Civil Engineering project is to provide students with an introductory experience in the design of a basic component of civil engineering practice. This group project requires the design of an efficient horizontal support structure, a beam, using a fixed amount of material. The beam is created on a computer using AutoCAD. The beam must meet certain specifications. A prototype of each of the five best beams is built and tested during the labs.

The purpose of the Mechanical Engineering project is to give students experience in designing a basic structure of interest to mechanical engineering applications. Groups of students are required to design an efficient load-bearing structure using a fixed amount of material. The structure is designed using AutoCAD and must meet predetermined dimensions and shape. All structures that fulfill the geometric requirements are prototyped using a state-of-the-art prototyping system. All structures are tested during the labs, applying a load until they collapse.

The purpose of the Electrical Engineering project is to introduce the students to typical test equipment employed in an electronics/computer engineering lab such as oscilloscopes, multimeters, and function generators. The students then utilize the equipment to perform simple measurements of a basic electronic circuit, the multivibrator, in an individual project. In addition, an introduction to current experiments being conducted in the medical engineering lab and a presentation of activities in the VLSI lab are provided.

The purpose of the Computer Engineering project is to visit a working nuclear attack submarine, the USS Pittsburgh, in order to obtain first-hand knowledge of several of its engineering subsystems. Students ask questions of the tour guides and submarine personnel in order to learn about: the buoyancy control system, the periscope optics system, the inertial navigation system, the torpedo ejection system, the atmosphere control system, the sonar control system, the electrical system, the fire control system, and the steering and diving system. Five of the above topics are selected by each student to be described in a two page written report.

The Systems Engineering project involves the design of a system and the solution of a linear programming problem using LINDO. This group project includes the consideration of factors such as the amount of food , nutrients, and cost involved in creating a Thanksgiving meal for ten people. The students must determine the food and nutritional combinations that meet all of the Reference Daily Intakes while minimizing spending to stay within a $100 budget.

4. Strengths of Course

We have chosen our staff with great care, insuring that the faculty and TAs comprise a heterogeneous group that mirrors our student population. Our faculty represent experienced professors from the various engineering fields: a computer scientist, a mechanical engineer, an electrical engineer and a systems engineer. The teaching assistants are either seniors or graduate students who are in the engineering school at GW. All are dedicated to and enthusiastic about the undergraduate engineering curriculum.

As near peer lab instructors, the teaching assistants provide role models with whom the students can readily interact. They also answer questions about courses they have completed, and relate their own experiences to their students. The TAs have become advocates for the students, helping the faculty keep a balance in the course, giving feedback on projects as well as problems and successes. They provide an excellent barometer of which aspects of the course are successful and which need improvement.

We have employed several techniques to encourage community building. Some of these include field trips, group activities such as team scavenger hunts, and team assignments, and a SEAS design contest in which students submitted their hand drawn graphics for the front and back of a t-shirt. The class then voted on the entries and the winning designs resulted in t-shirts that were distributed to the students.

The single most effective community building activity was an overnight retreat that included a Ropes Course. The first week of class, students, faculty and staff attended a nearby camp where we ate, slept, worked and played together. Students who would never have felt comfortable approaching each other were thrown together and have become fast friends. Instructors who previously had little meaningful face to face interaction with the students now recognize students they encounter on campus and engage them in casual conversation. One of the most humanizing experiences for everyone was having the professors participate in a Ropes Course where teams of ten had to rely upon one another in order to accomplish several physical tasks.

The scavenger hunt accomplished several goals. The students learned where their respective departments are located, where the professional engineering clubs hold meetings and events, and where the dean and registrar are located. We have received feedback that this was one of the most popular lab activities. The teams of students got to know one another during the exercise, the engineering staff enjoyed meeting the freshman, and the students had to locate, through ingenuity, significant places on campus.

Our course evaluation has been completed. The students agree that the faculty and TAs strengthen the course. We also received high marks for the course web page [8], the individual student web page project, and the retreat. The students enjoyed the group dynamics while working on projects but thought some needed more explanation and lab personnel to answer their questions as they learned AutoCAD and Lindo. Spoke lectures proved more interesting than hub lectures. Several students did attend spoke lectures outside of their assigned spoke. As a result some changed their major, however, the majority strengthened their resolve in their choice of major. We continue to work on the improvement of this course, having received valuable feedback from the first group of students to complete the re-designed course.

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