

Designing a Theme-Based Introduction to Engineering Course Sequence

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Abstract

In order to increase attendance and engagement of first-year engineering students in an Introduction to Engineering course, the course curriculum is being redesigned to include hands-on, theme-based projects. The first part of the course content revision is to determine the themes for investigation and the number of course sections allocated to each theme. The next part of the revision is to determine which topics that are currently a part of the course are essential and should remain. Once those topics are identified, they need to be distributed across the two semesters as evenly as possible so that students have the same amount of time to work on projects each semester. Finally, projects for each theme must be developed.

Introduction

The Freshman Engineering Program (FEP) at the University of Arkansas (UofA) was established in 2007 with the primary objective of increasing the retention of new freshman in the College of Engineering (CoE) to their sophomore year. This objective supports college-wide retention and graduation rate goals. Thus far, there have been increases in both retention and graduation rates as shown in Figure 1. Therefore, we believe we are providing our students with a solid foundation for success in engineering study.

A key component of the FEP is the Introduction to Engineering course sequence which serves as the first year experience course for new students in the CoE. The course sequence is offered as two, one-credit hour courses each semester of the first year. The students meet for two 50 minute lectures and one 50 minute drill section each week, as well as a 30 minute peer mentor meeting. This results in a total of 180 minutes of contact weekly. In general, lectures focus on engineering problem solving, drill sections focus on major selection and professional development, and peer mentor meetings focus on personal and academic success.

Recently, the FEP faculty has had an increasingly difficult time with on-time attendance and student engagement, and as a result, we have decided to re-design the Introduction to Engineering course sequence. The first phase of the re-design occurred during the 2011-2012 school year. The UofA implemented a common classroom response system, and students in the Introduction to Engineering course were required to have a response card for classroom activities. We began taking attendance and using the response cards to gather feedback during lectures. Generally, the response cards were successful in improving on-time attendance and participation in workshops. However, the students, for the most part, were still largely disengaged with the material presented in class. Therefore, the course content will undergo a major revision prior to the 2012-2013 school year to include theme-based, hands-on projects.

Students will select one theme for investigation during the Fall semester and a different theme for the Spring semester.

		Cohort Year				
		1998 – 2006 COE	2007 FEP	2008 FEP	2009 FEP	2010 FEP
2 nd -Year Retention	College of Engineering	61%	62%	69%	71%	70%
	University of Arkansas	82%	80%	85%	83%	86%
3 rd -Year Retention	College of Engineering	47%	50%	59%	56%	
	University of Arkansas	75%	74%	78%	75%	
4 th -Year Retention	College of Engineering	44%	47%	56%		
	University of Arkansas	71%	70%	74%		
4-Year Graduation Rate	College of Engineering	18%	29%			
	University of Arkansas	28%	37%			
5-Year Graduation Rate	College of Engineering	35%				
	University of Arkansas	52%				
6-Year Graduation Rate	College of Engineering	38%				
	University of Arkansas	58%				

Figure 1. Freshman Engineering Program Retention Report

Course Content Restructuring

The first part of the revision is to determine which topics that are currently a part of the course are essential and should remain. Once those topics are identified, they need to be distributed across the two semesters as evenly as possible so that students have the same amount of time to work on projects each semester. The next part of the course content revision is to determine the themes for investigation and the number of course sections allocated to each theme. Finally, projects for each theme must be developed.

Essential Topics

While the content of the Introduction to Engineering course sequence is flexible, there are some skills and topics which are deemed “essential” in order for first year students to become successful sophomore engineering students. Once identified, this content is distributed across the two semesters to allow equal time in each semester for the theme based projects. The essential topics in the Fall semester assist students in becoming acclimated to the CoE, ensure students understand the basic fundamentals needed to perform engineering calculations, and provide students with basic spreadsheet modeling tools. In the Spring semester, course topics focus on professional development, academic planning, and expanding basic engineering problem solving skills.

Fall Semester Topics

- Syllabus and Policies

For many students, the fall semester of college is first time they are given a syllabus for a course. Therefore, the syllabus is discussed in detail. Students are also introduced to the FEP Assignment, Conduct, and Grading Policies. The FEP Assignment Policy clearly defines the guidelines for properly formatting handwritten, word processed, and spreadsheet work submitted as an assignment. The FEP Conduct Policy defines the behavior which is consistent with students' training to become a professional engineer including respecting their classmates' right to a healthy learning environment and communicating with faculty and staff members properly. The FEP Grading Policy defines the guidelines for grading assignments, exams, and projects.

- Library Resources

Students are expected to incorporate a small research component into their theme-based projects, so library resources are introduced early in the semester. The engineering librarian demonstrates the university resources available for students to find reputable, scholarly sources, provides citation assistance, and presents tips for avoiding plagiarism.

- Departmental Information Sessions

Each of the nine CoE departments presents an information session. While the content of these sessions is left entirely to the individual departments, the hope is that the information provided will help the students in making an informed choice of major.

- Engineering Fundamentals

Engineering fundamentals consists of understanding basic numerical analysis needed by all engineering students. This includes significant figures, scientific notation, order of operations, unit conversions, and metric prefixes.

- Excel Basics

Students learn how to use built-in Excel functions and create their own equations. In addition, students learn how to create charts and graphs which will aid them in efficiently presenting information gathered during the theme projects.

- Academic Advising

Consistent, correct academic advising is a key component of the FEP. Therefore, class time is dedicated to academic advising. Students are provided with general information about courses they will need to take during the Spring Semester. They are given an opportunity discuss this with their peer mentor, and finally have a one-on-one

appointment with a Freshman Engineering advisor to schedule their classes for the Spring semester.

Spring Semester Topics

- Syllabus and Activities

As always it is important students understand the course syllabus. Students are also presented the list of activities beyond normal class work and projects they are required to complete during the semester. These include activities associated with professional development, transition to their major, and peer mentoring.

- Professional Development

One of the most well received parts of the Spring semester is the professional development activities element. Students participate in a series of in class workshops including resume writing, job searching, interviewing, and understanding diversity in the workplace. Students' complete a resume review with their peer mentor and participate in a mock interview with an alumnus. Students are also asked to complete two other professional development activities which may include corporate recruiting sessions, employer panels, job fairs, or other workshops.

- Departmental Recruiting Sessions

Students choose their engineering major during the first week of March. To help facilitate an informed decision, students are required to attend at least three departmental recruiting sessions during the month of February. These sessions are scheduled in the evenings and often involve tours of lab facilities.

- Engineering Fundamentals II

In the spring semester, students are exposed to the concepts associated with the Time Value of Money as well as retirement planning and loan repayment. They are also provided with additional spreadsheet modeling and analysis tools including descriptive statistics, pivot tables, and Excel solver.

- Academic Planning

Once students have selected their engineering major, advising focus changes from looking forward only one semester to planning their academic career. Students are again reminded of their requirements for graduating from the CoE including the math sequence, science course requirements, and university core electives. Students also have group sessions with their department to explain the specific requirements for their newly chosen major. Students then meet one-on-one with an advisor from their department to schedule classes for the Fall of their sophomore year.

Themes

During a staff retreat in December 2011, A group of FEP faculty, staff, and teaching assistants identified a set of characteristics that must be associated with each theme. These characteristics include projects that

- are multidisciplinary in nature so that students are exposed to several types of engineering within each theme;
- incorporate design aspects which must be completed through teamwork;
- include both a hands-on learning experience as well as a computing aspect;
- contain elements that are competitive in nature so as to spark most students' interest.

With these characteristics in mind, a list of potential theme ideas and associated projects was generated. Four themes will be developed for the 2012-2013 school year including Biomechanical, Computing, Robotics, and Structures. The FEP faculty will be teaching 16 sections of Introduction to Engineering in the Fall semester, so 4 sections of each topic will be offered.

Biomechanical Theme

Students will design mechanical systems to interact with living things. Potential projects for the Biomechanics theme include a water filter and a model of an insulin pump.

Water Filter Project – Many developing areas still do not have access to clean drinking water nor do they have the resources to install large-scale water filtration systems. Several researchers in the CoE [1] are involved in projects to address this issue. As one of the projects in this theme, students will design and build a small biofilter and test the resulting water quality.

Insulin Pump Project – Students will design and build a model insulin pump. This project will incorporate several engineering disciplines. Analysis will include the concentration of insulin delivered, the mechanical pump required to deliver the insulin, and the software required ensure the biological and mechanical aspects of the work together properly. We are planning to use the Lego Mindstorm® Kits for the models.

Computing Theme

Students will design, build, and field test a microcontroller. Currently, we are planning to use the Arduino microcontroller. This provides a tangible medium for students to interact with the abstract concepts learned in other courses related to the device and circuits, such as Electric Circuit Analysis. Projects in this theme will focus on circuit design, programming practice, teamwork, project planning and project execution. Although specific projects have not been selected for this theme, several ideas are readily available in the literature [2, 3].

Robotics Theme

Students will design and build a small robot to perform a variety of basic tasks such as navigating a maze and handling some objects. This will be done through the use of Lego Mindstorm® Kits, and we hope to include MATLAB into these projects. Again, specific projects

have not yet been selected for this theme, but several schools have successfully implemented similar projects [4,5,6].

Structures Theme

Students will design, modify, create, and optimize structures. Potential projects for this theme include a competition using the West Point Bridge Design simulation software and building a balsa wood structure.

West Point Bridge Design – Students can download free software to design and test a virtual truss bridge using realistic “specifications, constraints, and performance criteria” [7].

Balsa Wood Structure – Students will design and build a small structure using balsa wood and glue subject to various dimensional and weight constraints. Structures will be loaded with weight until failure. The structure that meets the specifications and can with stand the greatest load will be declared the winner.

Assessing Student Engagement

As a part of the end-of-semester evaluations, students will be asked questions regarding the effectiveness of the hands-on, theme-based projects in assisting them in their selection of engineering major. In general, will be asked to rates certain aspects of the projects using a 5-point Likert scale and allowed to leave additional comments and suggestions for improvement. We will make changes as necessary to the projects based on faculty, TA, and student feedback from the Fall semester, and students will be required to select a different theme for investigation in the Spring semester.

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