

# **A First-Year Experience Course Sequence for Engineering Students at the University of Arkansas**

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## **Abstract**

A new first-year experience program for College of Engineering students at the University of Arkansas was implemented in 2007. A key part of this program is a two-semester Introduction to Engineering course sequence. This paper summarizes our efforts in designing and implementing this course sequence. The primary objectives of the course sequence are to provide students with (1) an ability to apply a structured, engineering problem solving approach, (2) an understanding of and experience with the engineering design process, (3) an ability to facilitate engineering problem solving with appropriate computer skills including spreadsheet modeling, programming, and web page development, (4) an ability to make an informed selection of major within the College of Engineering, and (5) an opportunity to participate in professional development activities. These objectives are addressed using a series of activities, lectures, and workshops, the details of which are contained in this paper. This paper also identifies some of the challenges we have experienced while implementing this course sequence and our efforts to overcome them.

## **The Freshman Engineering Program at the University of Arkansas**

During the 2007-2008 academic year, the University of Arkansas (UofA) implemented the Freshman Engineering Program (FEP), a new first-year experience program for College of Engineering (CoE) students at the UofA. The objective of the FEP is to support the achievement of the retention and graduation rate goals established by the CoE<sup>1</sup>, with particular emphasis on the retention of new freshmen to their sophomore year. Meeting this objective requires establishing the foundation for the academic and professional success of new freshmen entering the CoE by:

- delivering appropriate educational content to FEP students so that they are academically and technically prepared to move on to a discipline-specific CoE undergraduate program;
- providing FEP students having Advanced Placement (AP) or transfer credit with opportunities to pursue more advanced coursework aligned with their academic interests;
- introducing FEP students to the various CoE disciplines so that they appreciate and understand the multi-disciplinary nature of the engineering and computer science professions;
- assisting FEP students who are undecided about their intended major with choosing a major appropriate for their skills and interests (the eight majors available to CoE students are Biological Engineering, Chemical Engineering, Civil Engineering, Computer

Engineering, Computer Science, Electrical Engineering, Industrial Engineering, and Mechanical Engineering);

- providing FEP students with academic, career, and personal advising in a proactive manner;
- fostering a sense of community among FEP students, other CoE students, the CoE faculty, and the balance of the UofA community.

The FEP is executed via two sub-programs – the Freshman Engineering Academic Program (FEAP) and the Freshman Engineering Student Services Program (FESSP). These sub-programs are executed by a faculty Director, two full-time professional staff members, two instructors, and five graduate teaching assistants.

### **The Freshman Engineering Academic Program**

The FEAP is a two-semester, thirty-credit-hour program designed on the basis of the common curriculum requirements of the eight, discipline-specific CoE undergraduate programs.

<b>Fall Semester</b>		<b>Spring Semester</b>	
Course	Credits	Course	Credits
Introduction to Engineering I	1	Introduction to Engineering II	1
Calculus I	4	Calculus II	4
University Chemistry I	3	Freshman Science Elective	4
University Physics I	4	University Core Elective	3
Composition I	3	Composition II	3

For the Freshman Science Elective, FEP students choose between University Chemistry II (with laboratory) and University Physics II. All eight CoE degree programs accept either course, but students are made aware of specific departmental preferences prior to spring registration. The University Core Elective can be any course that satisfies one of the requirements of the UofA core curriculum in the social sciences, humanities, and fine arts.

Like similar students at many of our peer institutions, a significant number of FEP students do not have the mathematics ACT score (27 or greater) required to enroll in Calculus I as a new freshman. Most of these students qualify to take Precalculus Mathematics. The FEAP changes slightly for these students as shown below.

<b>Fall Semester</b>		<b>Spring Semester</b>	
Course	Credits	Course	Credits
Introduction to Engineering I	1	Introduction to Engineering II	1
Precalculus Mathematics	5	Calculus I	4
University Chemistry I	3	University Physics I	4
University Core Elective	3	University Chemistry II	4
Composition I	3	Composition II	3

The University Core Elective moves to the fall semester, and University Physics I moves to the spring semester because Calculus I is a co-requisite. The Freshman Science Elective then becomes University Chemistry II. These students are then one math class behind at the end of the Spring Semester.

A few of our students must begin their mathematics courses in College Algebra (two semesters behind Calculus I), and a very small number must begin in Beginning and Intermediate Algebra (three semesters behind Calculus I).

In implementing the FEAP, extensive interaction with the UofA Fulbright College of Arts and Sciences is required. Most importantly, the FEP staff works closely with the Fulbright College to implement block scheduling for the Fall Semester. In the block scheduling system, each FEP student is assigned to a block consisting of 22–25 students. All students in a given block have similar class schedules.

### **The Freshman Engineering Student Services Program**

The FESSP provides proactive support to FEP students through summer orientation, academic skills and personal wellness workshops, academic advising, peer mentoring, supplemental instruction and tutoring, and extracurricular activities. The FESSP is housed in the 5500 sq ft Freshman Engineering Center. The Freshman Engineering Center includes faculty and staff offices, a peer mentoring center, a tutoring room, a project room, a 60-seat computer lab, and a large study lounge. The peer mentoring program is staffed by approximately 30 CoE sophomores, juniors, and seniors. Participation in the peer mentoring program is required as part of the Introduction to Engineering course sequence. The supplemental instruction and tutoring activities are offered via the UofA Enhanced Learning Center (ELC).

### **Overview of the Introduction to Engineering Course Sequence**

A key element of both the FEAP and the FESSP is the Introduction to Engineering course sequence. The primary objectives of the course sequence include providing students with

1. an ability to apply a structured, engineering problem solving approach,
2. an understanding of and experience with the engineering design process,
3. an ability to facilitate engineering problem solving with appropriate computer skills including spreadsheet modeling, programming, and web page development,
4. an ability to make an informed selection of major within the College of Engineering,
5. an opportunity to participate in professional development activities.

Throughout the courses, particular emphasis is placed on require students to prepare assignments that are neat, complete, and correct. Students are provided with an Assignment Policy that provides specific guidelines that must be followed to receive credit for all submitted assignments in the courses. Most students find that achieving a high grade in the Introduction to Engineering course sequence is a result of beginning assignments in a timely fashion, diligently following directions, and taking advantage of resources available for assistance.

### **Engineering Problem Solving**

A variety of engineering topics are used to train the students on applying a disciplined approach to problems in a traditional engineering context. The topics used to facilitate the engineering problem solving approach include Engineering Problem Solving Fundamentals, Statics, Statistics, Engineering Economy, and Mass Balances.

#### *Engineering Problem Solving Fundamentals*

The College of Engineering at the UofA has open enrollment, and the introductory math course for students in the Introduction to Engineering course sequence ranges from College Algebra to Calculus III. Therefore, we spend two weeks in the fall semester reviewing concepts such as unit conversions, scientific notation, significant figures, order of operations, and dimensional analysis. Students are encouraged to collaborate with classmates to complete a series of worksheets to demonstrate proficiency in these topics.

#### *Statics*

A traditional lecture approach is used to introduce students to the topic of mechanics and specifically to the sub-topic of rigid-body mechanics. Students receive instruction on vector addition, basic trigonometric functions, and the creation of simple free-body diagrams. Students are introduced to the Assignment Policy, and they are required to submit their statics notes to their peer mentors during their mandatory, weekly peer mentor meetings. Mentors provide students feedback based on their notes and suggest strategies to help students improve their note-taking skills. Mentors then discuss the importance of note taking as it relates not only to the Introduction to Engineering course sequence but all of their courses.

### *Statistics*

Students are introduced to the concepts associated with random variables and descriptive statistics using a traditional lecture approach. This topic also includes an introduction to basic spreadsheet applications as well as a team-based design competition.

### *Engineering Economics*

Students are introduced to the concepts associated with the time value of money, cash flow diagrams, loan payments, and evaluating equipment alternatives using net present cost. This topic includes a traditional lecture portion with a handwritten assignment and continues to introduce basic spreadsheet applications.

### *Mass Balances*

Students are introduced to the concepts associated with the conservation of mass. Particular emphasis is placed on creating process flow diagrams, writing the associated balance equations, and solving systems of linear equations both by hand and with spreadsheets.

## **Engineering Design Process**

Students are given several opportunities to learn about and implement the engineering design process. These activities also focus on developing team-building skills.

### *Balloon-Powered Vehicle*

The first activity students participate in during the course sequence is the Balloon-Powered Vehicle Project. This project is a team-based, open-ended, design competition. Students are given a brief description of the engineering design process and a set of materials with which to build their vehicles. Each team must create and submit sketches for three different vehicle designs. Teams then build and test prototypes for each design that are entered into a competition. Final project grades are based on intermediate deliverables, competition results, and creativity of the designs.

### *West Point Bridge Design*

This design activity follows the statics lecture and assignment. Students form teams and use the West Point Bridge Design software available on-line at <http://bridgecontest.usma.edu> to design a truss bridge. The purpose of the competition is to create a structure that meets all design specifications while minimizing total construction costs.

### *Catapult Competition*

This design activity is in conjunction with the statistics lecture and assignment. Students form teams and use pre-fabricated, adjustable, wooden catapults to perform an extensive set of experiments. Data from the experiments is analyzed using descriptive statistics and graphs

created using spreadsheets. Student then participate in a tournament-style competition in which they must use information from their previous experiments to determine the appropriate factor settings on the catapult to hit a set of designated target locations.

## **Computer Skills**

In the course sequence, we provide FEP students with the computer skills (including spreadsheet modeling, programming, and web page development) that can be used to facilitate the solution of engineering problems. In addition to the 60-seat computer lab in the Freshman Engineering center, the FEP owns 60 laptop computers that are used for classroom instruction. Specifically, we use Microsoft Excel 2007 and Visual Basic for Applications (VBA) behind Microsoft Excel to develop the basic spreadsheet modeling, data management, and programming skills of FEP students. We use HTML and PHP to develop the web page development skills of FEP students.

### *Basic Spreadsheet Applications*

Regardless of their specific discipline, engineers are often responsible for creating, manipulating, and evaluating data sets that include numerical values and text. As such, basic spreadsheet applications are included alongside the traditional lecture content resulting in many assignments having both a handwritten and a computer file submission. The topic of Statistics offers students an introduction to the use of spreadsheets as students learn to calculate and understand descriptive statistics using several built-in functions of Microsoft Excel 2007. Prior to the Catapult Competition, students learn to use Microsoft Excel to create meaningful charts and graphs through a series of self-paced exercises. In Engineering Economy, students learn additional formatting techniques and how to use cell references. Mass Balances gives students an ability to use the Solver add-in in Microsoft Excel to solve systems of linear equations.

### *Data Management*

After developing their basic spreadsheet skills, students explore more advanced features in Microsoft Excel including sorting, counting, logic, look-up functions, filters, and pivot tables. Students' proficiency in spreadsheet skills is evaluated through completing an in-class assignment and an individual oral exam.

### *Algorithms and Computer Programming*

A large portion of Introduction to Engineering II is devoted to developing algorithms and implementing them using VBA within Microsoft Excel. Beginning with simple programming, students apply concepts such as creating a VBA macro using a command button, declaring variables and constants, and input/output. Then, more complicated logic such as IF-THEN-ELSE and WHILE loops is introduced. Emphasis is placed on properly documenting code and providing sufficient instructions for other possible end-users.

### *Web Development*

For web page development, students first learn to create a personal webpage using HTML which must include various formatting options, pictures, links to another website, and their resume. Students then draw the wire frame and create a webpage (using PHP) which allows users to order items from a fictitious business of their design.

## **Major Selection**

Students do not select a discipline-specific CoE major immediately upon entry into the FEP. Through a series of departmental information sessions, alumni panels, and departmental recruiting sessions, students are educated about the eight disciplines within the college of engineering. By the end of the course sequence, they should be able to make an informed decision.

### *Departmental Information Sessions*

After the students have had a few weeks to settle into their coursework, we begin the process of introducing students to the various majors. Each week, faculty from one of the eight CoE disciplines presents the class with an overview of their department, their curriculum, and the associated career paths. Emphasis at this point is placed not on recruiting, but on only accurately informing students about the discipline.

### *Alumni Panels*

In addition to the information sessions, UofA CoE alumni are brought into the classroom to discuss their career. These sessions are interactive with the questions mostly coming directly from the students. Students are required to fill out simple worksheets as proof of attendance and attention.

### *Departmental Recruiting Sessions*

In the Spring Semester, students are required to attend the recruiting sessions for at least three different CoE majors. These sessions occur outside of class and usually involve tours through the departments' facilities and laboratories.

### *Decision Day*

By midway through the Spring Semester, the students should have enough information to make an educated decision about which discipline in the CoE they would like to join. The decision process culminates with Decision Day during which students declare their selected major in front of their peers and are welcomed to the department by faculty and other representatives of that new department. Usually the week before Spring Break, the date of Decision Day is set such that students will be advised for sophomore registration by their new departments.

### *Introduction to My Major*

The last few weeks of the Introduction to Engineering course sequence are intended to facilitate the students' transition into their newly-chosen majors. Students participate in special projects or competitions that focus on a discipline-specific problem. The classroom time is adjusted and special scheduling is used to accommodate single-discipline teams meeting together to complete the projects. This activity gives students an opportunity to meet and interact with the students with whom they will be interacting for the remainder of their degree program.

### **Professional Development**

The Career Development Center (CDC) at the UofA sponsors the Professional Development Institute (PDI) which consists of various career-building workshops allowing students to explore career options and learn job search strategies. The FEP works in conjunction with the CDC to provide a series of PDI workshops to our students. Students who complete the requirements for the PDI Career Planning Program before graduating receive a Certificate of Recognition from the CDC and a Letter of Commendation from the Dean of the student's college or school. During the 2008-2009 academic year, 84 FEP students completed the program.

### *Resumes and Job Search*

This resumes and job search workshop assists students with transitioning their high school resume to a professional resume focusing on university activities and accomplishments. Students are introduced to the co-op and internship opportunities available to engineering students as well as the UofA resources available for securing co-ops, internships, and full time employment. As a follow-up activity to this workshop, students create a resume and meet with a CDC counselor for a resume review. The student receives feedback on their current resume as well as suggestions for improvement. Students then submit their revised resume to their peer mentor for additional feedback and course credit. Students are then encouraged to attend the CoE career fair to explore options for future employment.

### *Interview Skills and Mock Interviews*

This interview skills workshop assists students with preparing for a job interview. The students are provided with tips for preparing for the interview and are made aware of the different types of commonly-asked interview questions. Appropriate dress for job interviews is also discussed. As a follow-up activity to this workshop, students participate in mock interviews with CoE alumni. Students are required to dress appropriately and bring a copy of their resume. Feedback from the interviewer is given to the student during their weekly peer mentor meeting. During the 2008-2009 academic year, two FEP students were offered summer internships as a direct result of their mock interview.



## Challenges

In three years of developing and offering the Introduction to Engineering course sequence, we have identified several key challenges in our retention battle. Our primary challenges associated with student's academic performance include their inability to organize course materials, prioritize course assignments, and develop skills not specifically addressed during course lectures. We also face significant challenges in the areas of academic honesty, personal responsibility, and social issues.

### *Organization*

On the first day of class in the Fall Semester, all students are given a binder that contains the course syllabus (in sheet protectors), divider tabs for each course topic, and relevant course materials behind each tab. Our students are also given a daily planner and a USB drive for storing electronic files. Throughout the semester, several notebook checks are performed during the students' weekly peer mentor meetings to encourage the students to maintain an organized, up-to-date, course notebook.

### *Study Skill Development*

In the Introduction to Engineering course sequence, we provide students with the majority of the skills required to complete course assignments. To encourage students to use their course notes and develop skills not specifically addressed in class, we allow ample class time for students to work on assignments, collaborate with other students, and ask questions to the instructor and teaching assistants. We also keep track of major exam dates in other courses. We encourage students to plan ahead by announcing test dates and hosting study sessions in the Freshman Engineering Center for major exams in their other courses.

### *Academic Honesty and Personal Responsibility*

Through class discussions and peer mentor meetings, we make students aware of the higher standards for academic honesty and personal responsibility that are expected of engineers in training. We convey it is now the students' responsibility to arrive to class on time, devote sufficient time to homework and studying, check their e-mail on a regular basis, and take responsibility for their education. These standards are often significantly higher than the expectations the students are accustomed to from high school and the transition is difficult for many of our students.

### *Social Issues*

Finally, students must learn to deal with the social pressures of the university. As a member of the university community, students have an opportunity to meet and interact with scores of new people including students who are not engineering majors. Often time, these "non-engineering" friends have courses that are significantly less demanding than the typical engineering student's

courses. As a result, there may be significant peer pressure to be involved in activities other than academics. While we encourage our students to enjoy social activities and “have a life,” they must strike a balance between socializing and studying. We tell our students that “engineering should not be your only priority, but it should be your first priority.”

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Dr. C. Richard Cassady is Director of the Freshman Engineering Program and Professor of Industrial Engineering at the University of Arkansas, where he has served on the faculty since August, 2000. As Director of Freshman Engineering, he is responsible for overseeing the development and operation of both the academic and student services components of this first-year experience program for College of Engineering students. This program was introduced during the 2007-2008 academic year. Dr. Cassady is an elected member of the University of Arkansas Teaching Academy, and he has received numerous teaching awards including the Charles and Nadine Baum Faculty Teaching Award from the University of Arkansas (2006) and the inaugural Imhoff Outstanding Teacher Award from the College of Engineering (2005). Dr. Cassady is a Senior Member of IIE and a member of Tau Beta Pi, Alpha Pi Mu, ASEE, INFORMS, and SRE. Dr. Cassady received his B.S., M.S. and Ph.D., all in Industrial and Systems Engineering, from Virginia Tech.