AC 2008-710: AN INNOVATIVE FRESHMEN ENGINEERING COURSE TO IMPROVE RETENTION

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An Innovative Freshmen Engineering Course to Improve Retention

Abstract

As part of a federally funded project to improve retention, the College of Engineering (COE) at Southern Illinois University- Carbondale (SIUC) has implemented a college-wide *Introduction to Engineering* course to replace the first-year introductory engineering courses offered by individual departments. *Introduction to Engineering* is an innovative course designed to reinforce the retention efforts of the COE by addressing several issues that hamper student success.

Introduction to Engineering adopts a holistic approach to keep students interested and excited about engineering. All engineering freshmen are exposed to different engineering disciplines through a combination of engaging and informative lectures, projects and seminars. The hands-on projects increase students' self confidence and teach them skills that a traditional classroom setting cannot offer. The course also aims to dispel the fear of mathematics, the primary reason for poor retention rates in many engineering colleges.

Three faculty members, representing the Civil, Mechanical, and Electrical and Computer Engineering Departments, which collectively receive 90% of the freshmen class, coordinate the course with the help of six teaching assistants. A separate team is responsible for regular collection and analysis of student feedback. General trends affecting students' academic performance are discussed at weekly meetings and applicable adjustments are made. All aspects of the course are supervised by the Associate Dean of the College.

The course was offered for the first time in Fall 2007. Although it is still too early to evaluate the success of the course after one semester, available assessment data, including students' perceptions of the course and their academic performance strongly indicate that the course will improve retention and graduation rates in the COE.

Introduction:

Retention of engineering students is critical to ensuring the adequacy of engineers to meet the demands of the industry. Recent statistics indicate a concerning decrease in the graduation rates, accelerating the research into engineering persistence [1].

Several researchers have attempted to identify early indicators of engineering persistence [1-4]. Daempfle [5] and Pascarella et al. [6] propose a variety of interdependent factors relating to the level of preparation of the incoming student, academic environment, and expectations about work and family. Many studies stress the importance of first-year college experience and students' self-perception of math ability in persistence. Jackson et al. [7] concludes that the first-year GPA is the best predictor of attrition. According to Besterfield-Sacre, M., et al. [8], adoption of an active learning format has the strongest impact on students' academic performance and their attitudes about engineering profession.[9]

Improving the freshmen experience has great potential for increasing retention which ultimately translates into a higher graduation rate. Many engineering institutions in the nation are developing and testing a combination of academic and non-academic programs to increase the retention and graduation rates. A variety of strategies, including revision of teaching methods and redesign of traditional classes are being implemented to improve freshmen experience as a whole. A recent nationwide survey by Brannan and Wankat[10] indicate that more than two-thirds of the engineering programs have a first-year introductory course to motivate students. While helping students choose a career path has been a traditional goal [11, 12], most such courses now include computational tools [9, 13] and hands-on design projects [14-20] that emphasize active learning.

Unfavorable nationwide trends, particularly the declining graduation rates prompted the College of Engineering (COE) to undertake a major initiative to improve retention. Current graduation rate in the COE is 37 %. With the help of federal funding, the COE implemented strategies to improve the retention rates by 30% within 4 years. Figure 1 shows the current and target retention and graduation rates at the COE.

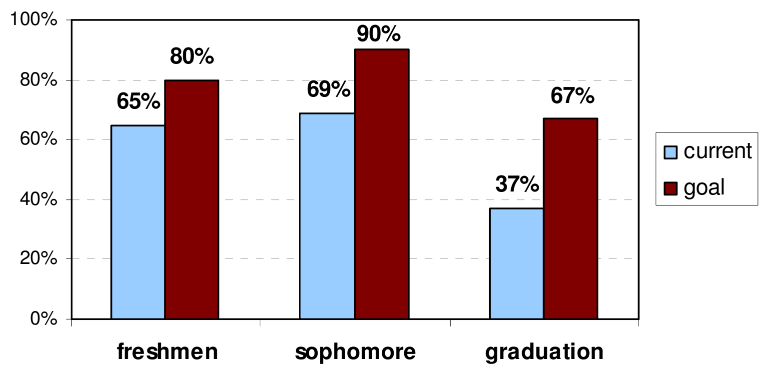


Figure 1. Retention and graduation rates at COE

The *Introduction to Engineering* course is one component of the COE's retention efforts, and has become a required freshman engineering course starting Fall 2007 Semester. Probably the most distinctive feature of the *Introduction to Engineering* course is its strong links with various components of the COE retention program, which are shown in Figure 2. For example, the course instructors also serve as faculty mentors who monitor students' performance in all the courses that they are taking. Simultaneous implementation of these components will strengthen the COE retention program.

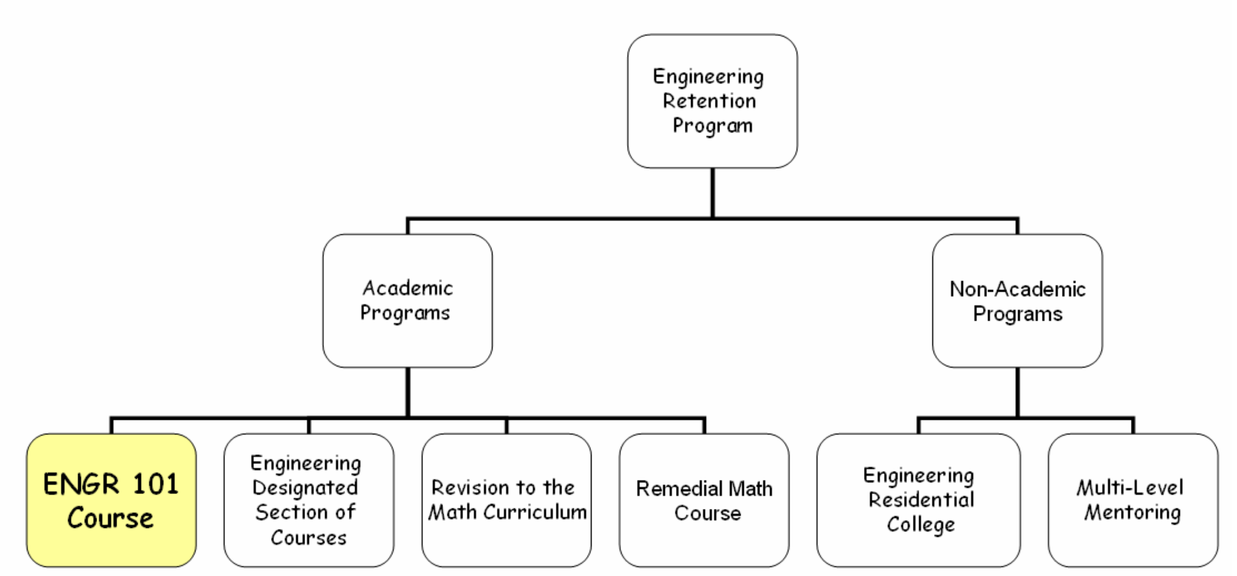


Figure 2. Components of the retention program at COE

The *Introduction to Engineering* course exhibits radical departure from the COE's tradition in which each engineering department in the College offered its own introductory course. Logistical problems related to scheduling, laboratory space, and equipment resources were resolved through a very concerted effort across the college. The course has been implemented with existing resources. This organization and development of Introduction *to Engineering* course is presented below.

Development of the Course:

Until Fall 2007 Semester, each department in the COE offered their own introductory course. The content of these courses varied widely from teaching computer applications to information about the faculty in addition to a basic overview of that particular engineering discipline.

Introduction to Engineering is a college-wide course that all freshmen are required to take. Unlike the traditional lecture-based setting, the course adopts a hands-on approach, rotating student groups through laboratories in the three engineering disciplines: electrical, mechanical, and civil. The hands-on projects are intended to keep students' interest while exposing them to a wide range of engineering applications. The students are expected to gain a better understanding of how fundamental principles of science and engineering apply to the profession and how knowing these principles prepares them for future courses. Also, the students appreciate the importance of math in engineering because their projects typically include a component that requires mathematical skills. Students learn software applications commonly used in the engineering profession, and are required to use the software to analyze data and write a project report.

Engineering curricula in many of the nation's universities include a course intended to expose the first year students to engineering. However, they are typically offered at the department level and concentrate on the particular engineering discipline. These courses are ideally suited to students who have made an informed decision about their major. Unfortunately, most students enter engineering with little engineering exposure and lack the necessary information to distinguish different disciplines. About 50% of engineering students switch majors before they graduate [6]. Allowing students to experience different areas in engineering is very important; currently all students in the COE must declare a specific departmental major as a freshman but many students are still somewhat undecided about their major. Some of these students lose interest and, therefore, it is very useful for these students to experience projects in different engineering departments and possibly change majors within the COE.

Objectives of the Course:

The main objective of this course is to enhance students' success by keeping them interested in engineering. Specifically, the course aims to

1. Help students understand and become familiar with engineering professions and careers.
2. Introduce students to the various technical areas and specializations within engineering.
3. Help students form academic and personal support groups and develop the ability to communicate and work effectively with others.
4. Acquaint students with the role of engineers in society and in engineering ethics.
5. Provide students hands-on laboratory projects and theoretical background to appreciate the importance of mathematics in engineering.
6. Guide students in choosing an engineering curriculum

Course Structure and Content :

The *Introduction to Engineering* course is a three-credit course that meets three times a week for fifty minutes. The course content is a well-balanced combination of informative and engaging lectures, hands-on projects, and distinguished guest speaker seminars. While the objectives and priorities of each discipline determine the breadth and depth of the course contents, recommendations from the industrial advisory board, faculty, and students are reflected in the final format of the course. The course has three main components: lecture, laboratory and guest speaker seminars.

Lecture Component:

The lecture component makes up 20% of the course. This component introduces the students to different engineering disciplines and exposes them to the interdisciplinary nature of real-life projects and the importance of teamwork and time management. This component also discusses the importance of self discipline, goal setting, effective communication and ethical behavior. Other topics covered in the lecture component include: professional organizations and societies, registered student organizations in the college, effective learning skills, and utilization of campus resources.

A notable feature of these lectures is the emphasis on active learning whereby student participation is highly encouraged, instead of following an instructor-led monologue format.

Each lecture is followed by an exercise, a short quiz or a survey depending on the particular topic, giving the students an opportunity to test their knowledge and provide feedback.

Laboratory Component:

The laboratory component consists of a series of hands-on projects and makes up 60% of the course. The students work in small groups and incorporate science and engineering principles to solve a given problem. Every project has a part that emphasizes the importance of mathematics in creating useful, safe, and economical products for the society. These projects are expected to clear up the students' common misconception that the first-year courses have no direct link to "real engineering". The difficulty level of mathematics is carefully adjusted to intrigue the students, not to intimidate or frustrate them. Also, working in small, randomly assigned teams enhances their team-work skills.

The hands-on projects covering the COE's three engineering disciplines have been carefully designed to be engaging and informative. One of the most notable features is the subtle incorporation of math into the projects. The goal is to impress upon the students that math, when applied to engineering problems, is very meaningful and not abstract. Microsoft Office, Matlab, AutoCad and West Point Bridge Designer (WPBD) Software are taught as part of the hands-on projects. At the end of each project, students prepare and submit a report using the software applications they learned. Instructions are given on report writing techniques and, depending on the project, either individual or team reports are required to be submitted.

The electrical engineering projects consist of three labs. The first lab-Digital Half Adder- is intended to teach students how to read digital schematics and translate them to a hardwired circuit. Students are exposed to the basic digital gates, the basics of computer design, and truth tables. At the end of this lab, the students are asked to simulate and verify their design using Xilinx IDE, and physically build the circuit using their newfound knowledge of switch design, microchip layout, and basic signal concepts.

The second electrical engineering lab- AC/DC Conversion- focuses on alternating current circuits, direct current circuits, their differences and everyday applications. In this experiment, students accomplish AC/DC conversion with both a half-wave and full-wave rectifier. After deriving and explaining the circuit equations, they are asked to do simulations in MATLAB or Simulink. Physically building the converter teaches the students to use the function generator for providing signal inputs and the oscilloscope for observing and measuring signal inputs and outputs.

The third electrical engineering lab -Amplitude and Frequency Modulation- concentrates on commonly used modulation techniques for transmitting and receiving signals. Students can easily relate to this topic because of its widespread use in everyday life, particularly for radio and television broadcasting. This project involves Matlab simulation of the modulation systems, and physical verification using function generators and oscilloscopes.

In the mechanical engineering project, teams of 4-5 students are asked to design, build, and analyze a small, hand-operated catapult which can launch a ping pong ball at least 10 feet with accuracy and precision. This project aims to expose the students to engineering design and data analysis while making them realize the differences between theory and experiments. The hands-on assembling and building part of the project makes them appreciate the importance of teamwork in a non-intimidating atmosphere. At the end of the project, each student is required to submit a report discussing the governing equations and results, using advanced functions of Microsoft Excel and Word.

The civil engineering component consists of three independent labs and a bridge design project competition. The block begins with one lesson in the classroom on how to use the West Point Bridge Designer (WPBD)- the software to use in their project. This part aims to provide an engaging hands-on introduction to engineering design process.

The second lesson of the civil engineering block is devoted to a hands-on activity where they practice drawing free body diagrams: The students are asked to check joint equilibrium of a three-member truss. This activity emphasizes the importance of basic trigonometry and equilibrium principles in engineering. In the next lab, students work in pairs to determine the spring constant of a spring-mass system by loading the system with predetermined increments and measuring the elongation. In the end, they plot the applied load versus the elongation and calculate the spring constant. The third lab involves determination of the coefficient of static friction using an inclined surface. After a brief discussion of friction and its importance, students are asked to work in pairs to perform 15 measurements and report the average and standard deviation of their measurements and discuss possible sources of experimental error.

The civil engineering component ends with the bridge design contest, where teams of 2-3 students compete to become the winners. This project emphasizes the importance of stress, strength, and optimization in design process, while strengthening the students' team work skills. After selecting an initial design, a series of modifications are applied to minimize the total cost estimated by WPBD. The cheapest bridge to survive the WPBD's load test with no members failing wins the competition and the members of the winning team receive certificates the last day of classes.

<u>Guest Speaker Seminars Component:</u>

The remaining 20% of the course is reserved for the guest lectures seminars presented by distinguished alumni who also serve as members of the College Industrial Advisory board. These members are highly committed to improving the college and have offered to help make the entire retention program successful. Typically, their seminars are designed to be informative and motivational. The seminars discuss the role of an engineer and stress the importance of leadership, teamwork and time/resource management. Industrial mentors also offer career advice that motivates the students to remain in engineering and obtain summer internships later in their college education.

Assessment:

The main assessment tool for the course assessment was the student surveys. To see the effect of the course on attitudes towards engineering, students were given a survey in the beginning of the semester. At the end of the semester, in addition to the post-attitudes survey, students were asked to complete another survey on course assessment. Of the 204 students enrolled in the course, 185 students responded to the survey. Student responses were rated on a five-point Likert scale with the following labels: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D) and Strongly Disagree (SD). The response categories were scored 5 (Strongly Agree) to 1(SD) Strongly Disagree. Table 1 shows the survey questions and the students' responses.

Table 1. Student Responses to Course Assessment Questions

			Percent of Responses (*N* = 185)				
Item	*M*	*sd*	SA	A	N	D	SD
"The course increased my familiarity with different professions and careers in engineering."	3.96	0.88	25.9	53.3	13.3	5.9	1.5
"The course increased my knowledge of the different engineering disciplines."	3.83	1.00	23.0	53.3	10.4	10.4	3.0
"The course helped me to develop my ability to work effectively with others."	3.47	1.13	17.0	41.5	17.8	18.5	5.2
"The lab projects provided hands-on experience in a variety of engineering disciplines."	3.87	0.90	20.7	56.3	14.8	5.2	3.0
"The course helped me make a more informed decision about my academic major."	3.56	1.10	17.0	47.4	15.6	14.8	5.2
"The course helped me to feel like I am an integral part of the College of Engineering."	3.53	1.08	17.0	41.5	24.4	11.1	5.9
"The course helped me gain a greater appreciation for the role that math plays in the engineering field."	3.50	1.06	14.8	45.2	20.0	15.6	4.4
"The course helped me gain a greater appreciation for the role that science plays in the engineering field."	3.51	1.06	15.6	42.2	25.2	11.9	5.2
"The course helped me to approach problem solving with more creativity."	3.50	1.06	15.6	41.5	24.4	14.1	4.4
"I am more confident that I will successfully complete the engineering program as a result of the course."	3.38	1.20	17.8	34.8	23.0	14.8	8.9

M= mean, sd = standard deviation, SA = Strongly Agree, A = Agree, N = Neutral, D = disagree, SD = Strongly Disagree, NR = No Response.

When asked what they liked about the ENGR 101 course, students frequently mentioned labs/hands on projects (n = 33) and exploring different disciplines (n = 24). Sample student responses are listed below:

"Engr 101 is a good class for students interested in engineering but unsure of what discipline."

"I really liked the hands on projects. The informative lectures were interesting but the projects were much more exciting."

"That we got to experience a lot of different projects that all engineers do"

"I liked that there were so many engineering freshmen in one class. It almost forced us to establish help networks"

"I liked the way all the students got to interact with each other. I like the labs and getting to know different students and professors."

"The way they made engineering seem right for me. The[y] explained engineering very well and explained what we could do with an engineering degree."

"Working with different groups of people & gaining information & experience about other disciplines within engineering"

"It allowed me to see and experience all disciplines of engineering."

"Showing me the many different discipline and job possibilities"

"Taught every discipline of engineering, not just one."

In response to the question regarding how the course could be improved, students responded: nothing (n = 17), more hands-on projects (n = 16), more discipline-specific (n = 14), better organization (n = 13), and less lectures on non-engineering topics (n = 12). Sample student responses to this question include:

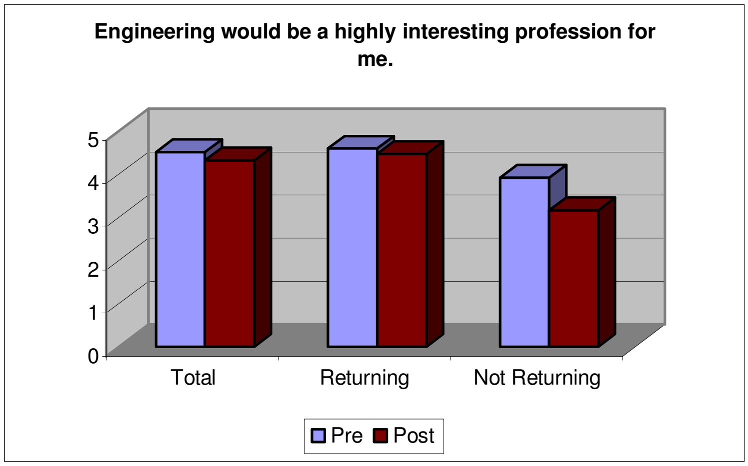
"Smaller classes, more organization, more interesting assignments."

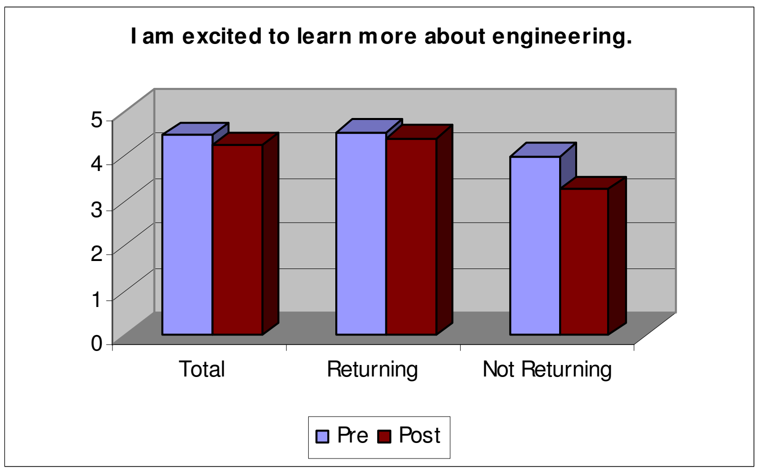
"Less lectures in the beginning & more hands on"

"Smaller group or class sizes, less time spent on study skills and more time spent on the disciplines"

"Talk more about specific jobs engineers can have; not just the general field."

When asked about their intentions for the following semester, 88% of respondents said they would be returning to the COE. Attitudinal differences were found between students planning to return and those not returning to the COE. Figure 3 shows the pre- and post attitudes on a 1to 5 scale.





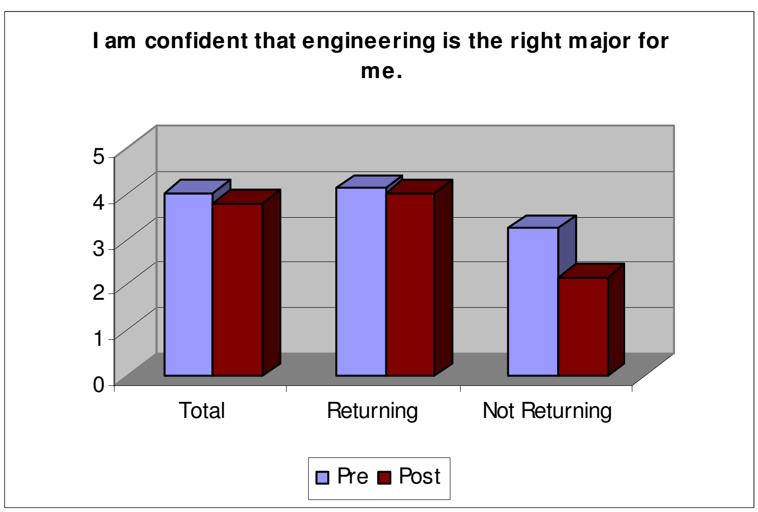


Figure 3. Pre and Post Attitudes (5 = Strongly Agree and 1 = Strongly Disagree)

The pre- and post surveys about attitudes toward engineering showed a slight drop in the means from the beginning to end of the course. Considering the current freshman retention rate at the COE is 65 %, some drop is inevitable. Overall, students continued to have strong positive attitudes about engineering.

Conclusion:

Introduction to Engineering (ENGR101) is a three-credit freshman course aiming to help overcome some of the problems that are faced by freshman engineering students in the College of Engineering (COE) at Southern Illinois University-Carbondale (SIUC). The course is a component of a federally funded retention effort.

The structure and format of the course is under continuous revision. To improve the success of the course, the instructors are continuously revising the course content and incorporating ideas and suggestions from the students and the COE faculty members.

Most students who took the course in Fall 2007 thought the breadth of technical content and the level of difficulty of the course were appropriate, and they were motivated by the course. One concern common to students, teaching assistants and the instructors was that the size of the groups, averaging 30 students per group. Effective Spring 2008, the groups are now limited to a maximum of 15 students. In response to the students' ideas regarding possible improvements to the course, the instructors are now developing additional activities and hands-on projects for use in future semesters.

Considering that the course was offered for the first time in Fall 2007, it is still too early to realistically estimate the effect of the course on retention. However, available assessment data strongly indicate that the course will improve retention and graduation rates in the College.

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