A New "Contact-Based" First Year Engineering Course

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Abstract - *A new first year engineering orientation course has been put in place. The course stresses integration with other first year courses, writing, team building, critical thinking, disciplinary thinking, and has a strong problem solving component. Students were randomly selected to participate in the course. Students' attitudes about engineering and the first year experience were assessed using an instrument developed by Besterfield-Sacre and Atman [1] and compared with the normal introduction to engineering course. Students in this course were more positive about their learning experience in the first semester, reported a higher satisfaction with all their courses, and were less likely to think that the first year courses were designed to "weed" students out of the program.*

Introduction

Most freshmen engineering orientation courses have as a major function the dissemination of information and introduction to the "engineering life." Unfortunately, most courses carry little if any academic credit and stand alone in the first year with little interactions with the basic sciences being offered at the same time. Most introductory courses focus on technical content [2] and avoid the connections necessary to put engineering in context within the entire curriculum. Students who selected and were accepted into engineering programs generally became interested in engineering because of the strong mechanical connections and often question where the engineering is in their first year courses. Usually, they are told it will come later after they have mastered the basic sciences; it is the trust me approach. Too often, students leave engineering without ever experiencing the challenge and reward of solving an engineering problem. Recently, however, there has been a nationwide effort to create experimental courses to stress design [3,4,5], "hands-on" mechanical dissection [3,5,6], and considerable problem-solving.

North Carolina State University has had a freshman engineering course, E100, in place for several years. The course carries no academic credit, meets for one hour per week, and is presented to 800-950 students, approximately 150-160 students per section. The content includes matriculation procedures, advising strategies, academic integrity, study skills, elective selection, and all the "rules of the road" necessary for success. Since it carries no academic credit, little if any outside work is assigned and the students quickly realize it is not a normal academic course. Students are required to attend several departmental information sessions and some of the smaller departments are invited to make in-class presentations.

Our motivation to change the orientation course stems from a desire to inculcate engineering problem solving early in the curriculum as a way to stimulate interest in engineering disciplinary thinking. We believe that students' interest in engineering is very high when they enter the program but decreases during the first year. By presenting connections to engineering disciplinary thinking early, students should be better able to understand the relevancy and necessity for related basic science courses. We also expected that an enhanced interest in engineering would lead to higher matriculation rates, increased retention, and ultimately a higher graduation rate.

College of Engineering First Year

The "normal" first semester academic load for engineering students is calculus I (MA 141), chemistry (CH101), composition and rhetoric (ENG 111), orientation to engineering (E100), introduction to computing environments (E115), and a humanities or social science course. The E115 course is designed to acquaint students with the distributed UNIX based computing system and its capabilities and is prerequisite for the computer programming course, either FORTRAN or C^{++} taken during the spring semester.

Other introductory engineering courses have been offered to a limited number of interested students; IMPEC, an integrated approach to math, physics, engineering, and chemistry [4,5], E123, a mechanical dissection course which is now linked with the first year writing and composition course [6,7], and ECE 292D, a hands-on team based design course offered to upper class students as well [8,9]. However, all of these special courses have limited enrollments due to space and equipment limitations and would be difficult to scale up to the necessary 960-1000 enrollment per semester. All first year students from underrepresented populations are enrolled in E144, Academic and Professional Preparation for Engineers. The course stresses career development, study skills, note taking, team building, and success strategies.

With the assistance of funding from our Provost's Office and the National Science Foundation, we have put in place a new freshmen engineering course that is a first step scale up borrowing from the other special introductory courses. This new course, E497F, stresses contact, team

work, writing, integration with the concurrent freshmen computer literacy course, and problem solving strategies, in addition to the "normal" content covered in E100.

One goal was to inculcate engineering problem solving strategies while allowing students to inductively discover how the various engineering disciplines approach problem-solving. The course was also assigned 2 credit hours and was letter graded. Early assessment is based upon the "Attitudes About Engineering" survey developed by Besterfield-Sacre, *et al*. [1].

The Course (E497F Engineering Problem Solving)

Early in the planning, we realized that to be effective as a test course, we would need a random selection of students. From the total incoming freshmen class (N=946), a random selection of 275 students was chosen with the same percentage of women and men as the entire freshmen engineering class. These students were notified that they had been selected to participate in a new optional freshmen engineering class. They were told that it would carry academic credit, would require considerable out-of-class work, be integrated with the computer literacy course (E115), and would require submission of several major projects. Only five students notified us they would rather not participate. Several students opted for other first year courses or had scheduling conflicts that were not resolvable resulting in a final enrollment of 224. Prior to summer orientation, students were scheduled for a weekly large lecture, and special sections of the computer literacy course. The plan was to have students attend E115 every week for the first 4-6 weeks, and then every other week with the off week reserved for engineering problem solving sessions assigned in E497F.

From the first class on, it was made obvious to the students that this was a total participation class; brainstorming sessions, team projects, in-class team work, modeling exercises, discussion of homework, and discussions of the assigned computer problems were commonplace. Students were expected to maintain a journal containing all homework assignments, discussions, and comments on assigned readings. The texts were Landis' *Studying Engineering* [10] and a handbook for the NC State University College of Engineering programs. Journals were randomly collected each week.

Very little lecturing occurred in the class; team based problems were chosen to illustrate the intended points. In all instances, a team leader and a process recorder were selected, and teams were expected to report to the entire class when called upon. Typical questions put to the class included:

- in groups of three, brainstorm and develop a concept for disposal or handling of hog waste; identify the types of engineers/ scientists/ professionals/ others that should be part of the team and why; identify potential problems and/or risks in your approach to dealing with them.
- in groups of three, develop a concept for the disposal of low level radioactive waste assuming the site has been selected; identify and justify the members of your team; identify risks, dangers, and/or problems.
- in groups of three, identify five products not currently available that would do well in the market.

These brainstorming exercises were intended to encourage and develop group attitudes and interactions, to allow all students to be heard, to develop a sense of what is needed to conduct an engineering project, and to discover what different engineers can and really do in the "real-world." Some of the exercises were intended to simply develop group attitudes and some to let students discover the connections to other courses.

Most students complain about their first year writing courses and the following was conducted during the second class period:

- the entire class of 135 was asked a simple question – "why is English and writing important to an engineer?" – and asked to individually volunteer answers. After 10 minutes of tugging examples from individuals, the problem at hand was restated:
- in groups, brainstorm and itemize everything that you as an engineer will ever do that requires writing and communications; prioritize the top ten; go back through your list and identify those that you are all proficient in at this point in your life. [2]

It did not take long for the students to discover why English and writing are essential courses even in a rigid engineering curriculum.

Some "lecturing" occurred throughout the semester on learning and teaching styles, study strategies, approaches to learning, cooperative and collaborative learning techniques, approaches to learning, time management, and tips for test takers. Rather than lecture on different engineering disciplines, the in-class discussions were designed to allow students to *discover* what different engineers do.

At the end of the fourth week, the first major engineering assignment was presented: optimization of thermal insulation in home construction. By this time, students had been exposed to spread sheeting and graphics in the computer course, and had discussed problem solving in the E497F lecture. Students were required to submit individualized reports with background information, spreadsheets, graphs, sample calculations, and technical discussions. The reports were graded twice; once by the E115 instructors, and once by the engineering instructors. As this was the first real technical report required of our freshmen, the results were quite varied and ranged from very good to poor. It was obvious that the incoming students had never been expected to write a real technical lab report or to think critically about the question at hand.

The second major engineering project, a chemical engineering reactor design problem, was assigned during the last four weeks of the semester and required considerably more critical thinking and analyses. The assignment was basically a third year chemical engineering problem scaled down somewhat for first year students. It required the same basic analysis as the first but also required consideration of

ethics, safety, and economics. This was a major challenge to most students since they had never been asked to do anything like it. It did require some math, a little chemistry, some economics, and writing; but the major emphasis was on problem solving and communication of technical information.

Methodology of Assessment

The College of Engineering has been using a modified version of the "Student Attitudes About Engineering" survey developed by Besterfield-Sacre [1] since 1995. The survey is administered early in the fall semester and again at the end of the semester to all first year engineering students. We were then able to conduct analyses by groups, gender, type of engineering course, etc. The survey has been described by Besterfield-Sacre [1,11,12]. We have conducted analyses by gender [14,15] and for this paper we describe differences between the new special course (E497F) and the normal introductory course (E100).

The questionnaire contained 50 common questions for the survey administered early in the semester (the pre-test) and that administered during the last week of class (the post-test). In addition, there were twenty additional questions on the pre-test dealing with students' preparation, parents level of education, expectations about part time jobs, and level of preparation in high school. The post-test had additional questions designed to assess confidence in the basic courses, impact of the introductory engineering course on self assessed skills in problem solving, time management, writing, speaking, group work, study skills, etc. (see Table IV).

The Wilcoxon rank-sum test was employed to determine significant differences between groups. Wilcoxon tests were also run on the differences between the groups to measure change in attitudes for E100 and E497F.

Results

The College of Engineering enrolled 946 students in the fall 1996 cohort. The distribution by gender and ethnicity are shown in Table I as well as the fall GPA and SATM. All but 16 freshmen were enrolled in one of the orientation courses and the distribution in all introductory engineering courses is shown in Table II. It should be noted that all underrepresented populations are pre-enrolled in E144 and not required to take another introductory engineering course.

Students were included in the analysis of each individual question only if they responded to that question on both the pre- and post-tests. For most questions, the answer scale ranged from 1 = strongly disagree to 5 = strongly agree. For the questions dealing with the students' confidence, the answers ranged from 1 = not strongly confident ‡ to 5 = strongly confident.

As indicated in Table III, there were not many significant differences between the regular E100 and E497F students in terms of their abilities and skills related to engineering. Although there were significant differences in every category in Table III when analyzed by gender [14,15], there were few significant differences between the students in different introductory classes. However, confidence in engineering and knowledge about what an engineer does increased for the E497F students, which were goals for the course. The differences in the enjoyment of solving problems in different ways is related to the fact that the regular E100 assigned no engineering problem solving and E497F assigned several problems with open ended problem solving in mind.

Table I. Demographics and Student Performance of the 1996 Engineering Cohort

	All COE	E100	E497F
N	946	349*	203*
Female	21.2%	16.6%	29.1%
Male	78.8	83.4	70.9
White	80.0%	92.3%	96.1%
Afr-Amer.	13.0	0.3	0.0
Am. Indian	0.7	0.0	0.5
Asian	4.9	6.6	3.4
Hispanic	1.4	0.9	0.0
SATM	630	636	638
Fall GPA	3.03/4.0	2.99/4.0	3.14/4.0
First Year GPA	2.89/4.0	2.85/4.0	2.97/4.0

* only students who completed both the pre- and post-test

Table II. Fall 1996 Enrollments in First Year Engineering Courses

Fall 1996 Enrollments	
Course	N
E100	460
E123	47
E144	123
E497F	224
IMPEC	36
ECE 292	40
none	16
	946

‡ *"Not strongly confident" is the actual wording which appeared on the questionnaire. Even though the literal interpretation of that phrase would mean anything other than "strongly confident," including being merely "confident," we feel the students interpreted that response as meaning that they were very much lacking in confidence.*

Table III. Confidence in Abilities and Skills Related to Engineering

	1996 Class Responses					
	Pre Test		Post Test		Change	
Basic engineering knowledge & skills	E497F	E100	E497F	E100	E497F	E100
Confidence in physics	3.71	3.77	3.72	3.72	0.01	-0.05
Confidence in calculus	3.94	3.88	3.87	3.89	-0.07	0.01
Confidence in engineering	3.60	3.78	3.70	3.79	0.10	0.01
Confidence in computer skills	3.41	3.59	3.55	3.64	0.14	0.05
Engineering Skills						
I feel I know what an engineer does	3.20	3.51	3.50	3.63	0.30	0.11
Creative thinking is one of my strengths	3.78	3.76	3.70	3.63	-0.08	-0.12
I have strong problem solving skills	3.79	3.83	3.73	3.74	-0.06	-0.09
I feel confident in ability to succeed in Eng.	4.14	4.09	3.96	3.89	-0.18	-0.20
I am good at designing things	3.49	3.60	3.49	3.53	0.00	-0.06
I consider myself mechanically inclined	3.59	3.74	3.61	3.65	0.02	-0.10
I consider myself technically inclined	3.70	3.84	3.64	3.76	-0.06	-0.07
I enjoy solving open-ended problems	3.67	3.58	3.65	3.54	-0.01	-0.04
Enjoy problems that can be solved different. ways	4.04	3.87	3.88	3.79	-0.16	-0.08

shaded cells indicate significant differences at $p < 0.05$

The questions unique to the post-test concern the students' confidence in the entire first year curriculum and the assessment of the effect of their engineering course on skills we believe are essential to disciplinary thinking and the ability to succeed in engineering. As shown in Table IV, there were significant differences between the courses in 31 of the 41 questions.

It is important to note that the E497F students were randomly selected from the freshmen class and we therefore expected few significant differences. Statistical tests confirmed our expectation. However, the questions tabulated in Table IV indicate considerable differences in the students' attitudes and confidences during the fall semester. The E497F course stressed team work and cooperative learning in every exercise assigned in class and most of the out-of-class assignments. We also stressed the interdependence of the engineering disciplines as well as disciplinary thinking. If students reported that a civil engineer was needed for a given task, they were immediately asked to justify their choice. Furthermore, they were asked to explain the specific skills needed for any given task at hand.

The first five questions in Table IV were designed to determine the students' overall opinion of the first year engineering curriculum, generally calculus I, chemistry, chemistry lab, English, introduction to computing, and introduction to engineering. Although both groups agree that the curriculum is challenging, the E497F students were more satisfied with the pace, reported less of a demand, and were less likely to view the first year as a set of "weed-out" courses. They were also more "team-oriented" and reported that engineers are less likely to compete. Both groups agreed that the curriculum is challenging.

The second group of questions in Table IV refers only to the introductory engineering courses and excludes the introduction to computing course. Both classes met once a week in the same large auditorium setting with approximately the same number of students. The E497F class had an additional small class session (21-24 students) held in the computing labs every other week. The students in E497F reported a greater liking for their course, looked forward to a higher degree to learning more about engineering, felt they had a higher level of problem solving skills, and found the course more meaningful than did those in E100.

Students in E497F reported a higher level of confidence in problem solving and felt they could think creatively in their engineering course. This was an intended outcome for the course and most of the assignments were designed to reward creativity in problem solving as well as modeling. An unexpected outcome was a higher reported satisfaction with the quality of engineering advising. All students in engineering are advised according to their preference for a major or by the undesignated staff if they have no initial preference for a major. The class had a strong component on how to talk with your adviser, as well as learning and teaching styles; and we believe this helped students learn how to interact with their advisers more effectively than the students in the E100 class.

The last set of questions focused on the effects of the engineering course on several skills, a self assessment of understanding of the basic science courses, and whether the course helped students decide if engineering was the right field for them. For the eight "skills" questions, the E497F students reported a significantly more positive effect due to their engineering course in every area except for speaking skills. This was expected since both E100 and E497F were taught in large lecture format that was not conducive to

Table IV. Questions on Post-Test Only and Responses by Orientation Course

	Responses		
	E497F	E100	Difference
The pace is too fast in the engineering curriculum.	**2.52**	**2.75**	– 0.23
The engineering curriculum is challenging.	3.98	3.98	0.00
Instead of working together, engineer's tend to compete against one another.	2.52	2.70	– 0.18
The freshman engineering curriculum is too demanding.	**2.33**	**2.53**	– 0.20
I feel like the courses I have taken are designed to eliminate weaker students.	3.22	3.43	– 0.21
Questions about "engineering courses" and "engineering instructors" refer ONLY to the engineering course and not to E115 or to science and math courses.			
I like the type of courses required.	**3.35**	**3.15**	+ 0.20
So far, engineering does not challenge me.	2.66	2.70	– 0.04
I think my engineering instructor is a good teacher.	**4.12**	**3.34**	+ 0.78
The engineering instructor expects too much from the students.	2.34	2.33	+ 0.01
The grading system used is fair.	**3.66**	**3.35**	+ 0.31
Class sizes are too large for effective learning.	2.66	2.83	– 0.17
The engineering instructor shows concern for me as an individual.	**3.32**	**2.95**	+ 0.37
I feel I have learned problem solving skills.	**3.44**	**2.99**	+ 0.45
The course work is too difficult.	2.23	2.41	– 0.18
My engineering instructor is available for help.	**3.70**	**3.44**	+ 0.26
I look forward to learning more about engineering.	**4.03**	**3.86**	+ 0.17
I feel like I can think creatively in my engineering courses.	**3.68**	**3.49**	+ 0.19
I do not find the content of the engineering course work meaningful.	**2.34**	**2.60**	– 0.26
The engineering instructors has knowledge about what he/she is teaching.	**4.21**	**3.60**	+ 0.61
I do not enjoy working with computers.	2.09	2.33	– 0.24
I am happy with the quality of engineering advising.	3.55	3.36	+ 0.19
I plan to continue in engineering in my sophomore year.	4.24	4.06	+ 0.18
The engineering course has had a positive effect on my:			
problem-solving skills.	**3.78**	**2.82**	+ 0.96
study skills.	**3.25**	**2.90**	+ 0.35
teamwork skills.	**3.46**	**2.85**	+ 0.61
time management skills.	**3.39**	**2.97**	+ 0.42
reading skills.	**2.87**	**2.63**	+ 0.24
writing skills.	**3.51**	**2.56**	+ 0.95
speaking skills.	2.67	2.57	+ 0.10
computer skills.	**4.04**	**2.87**	+ 1.17
knowing that either I do or I do not want to major in engineering	**3.84**	**3.56**	+ 0.28
knowing that I do want to major in engineering	3.74	3.56	+ 0.18
my appreciation of the role of engineers in society.	**3.84**	**3.45**	+ 0.39
I got a good grasp of the course content in CH 101.	3.71	3.68	+ 0.03
I liked CH 101.	3.03	3.07	– 0.04
I got a good grasp of the course content in MA 141.	3.62	3.62	0.00
I liked MA 141.	3.08	3.38	– 0.30
I got a good grasp of the course content in E 115.	**4.12**	**3.68**	+ 0.44
I liked E 115.	3.33	3.24	+ 0.09
I got a good grasp of the course content in my engineering course	**4.07**	**3.68**	+ 0.39
I liked my engineering course.	**3.86**	**3.05**	+ 0.81

shaded cells indicate significant differences at $p < 0.05$, bold numbers at $p < 0.01$

student speaking skill development. The self assessment of grasping the contents of math, chemistry, the engineering course, and computer literacy and the liking of these courses indicated that all the students were about the same for the chemistry but the E497F students had a lower liking for calculus. Both groups were the same in liking the computer literacy course but the E497F students were significantly higher in grasping the content. For the engineering course, the E497F students were significantly higher in both assessments.

Conclusion

The E497F course was designed to give first year students a taste of engineering thought processes and problem solving methods in the first semester on campus. The results of the attitudes survey indicate that students who enroll in this course are generally more positive about their academic experience than are those who enroll in the traditional orientation course. Particularly because this new course can be scaled up to accommodate an entire freshmen class of 1000 students, it looks quite promising.

For the 1997-98 academic year, plans are to offer this course to the same number of students. Additional team based, semester long projects will be assigned, and writing and speaking assignments will be emphasized even more. Our plan is to offer this course to all entering students beginning in fall of 1998.

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