
The Engage Program: Implementing and Assessing a New First Year Experience at the University of Tennessee

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ABSTRACT

The Engage initiative at the University of Tennessee addresses the needs of entering engineering students through a new first year curriculum. The program integrates the engineering subject matter of the freshman year, teaches problem solving and design by application, and seeks to address the increased retention and graduation of engineering students. Noteworthy curriculum features of the Engage program include a hands-on laboratory where students do physical homework to practice the concepts introduced in lectures, placing all freshman engineering students in a year-long team design curriculum, and a team training course where engineering upperclassmen are trained in team facilitation techniques and placed as facilitators with the freshman design teams.

The Engage program was piloted during the 1997–98 academic year with 60 students. In 1998–99, the program was scaled up to 150 students, and fully implemented with the entire freshman class of 465 students during the 1999–2000 academic year. Engage students have shown a significant increase in academic performance compared to students following a more traditional curriculum. Graduation statistics show the positive long-term results of this effort.

I. INTRODUCTION

Beginning in the fall of 1996, a team of faculty and administrators worked to redefine freshman engineering at the University of Tennessee (UT) to improve the effectiveness of the students' educational experience in their fundamental courses. Motivations to undertake this task have come from numerous sources, including Accreditation Board for Engineering and Technology (ABET) and industrial advisory boards, and they are familiar to engineering faculty around the country.

The deliberations of the development committee paralleled those at other universities where there has been a fundamental re-thinking of the methods used in undergraduate engineering education. Industry has consistently asked that graduates have skills in teamwork and communication along with technical competencies. The ABET engineering accreditation guidelines for engineering schools show that future curricula will be strongly influenced by these industry requests. Two studies by engineering educators, one sponsored by the National Science Foundation (NSF) [6] and the other by the National Research Council [1], both emphasized the need to move the curriculum in the direction suggested by our industrial customers.

Several learning models have been applied by engineering educators, including the Kolb (4MAT) model [3], the Hermann model [4], and models based on the Myers-Briggs test [5]. These learning models are consistent in arguing that engineering problems are best solved when approached with a sequence of different viewpoints, all of which must be given proper consideration to ensure a successful result. Individual students, regardless of their preferred learning approach, must be given practice in using a variety of other viewpoints in order to be successful problem solvers. In addition to analytical practice, students must also practice problem formulation, visual and tactile thinking, idea generation, and communication skills. This wide ranging skill set is difficult for any student to master, giving additional importance to the concept of engineering teams where the individual skills of a team's membership help complete the problem solving cycle. The Engage development team believed that successful curriculum reform must offer multiple teaching techniques to maximize student learning and interest.

A pilot program of the Engage curriculum with 60 students enrolled was offered during the 1997–1998 academic year. The program was scaled up to 150 students the following year (1998–1999). Beginning in 1999–2000, all entering freshmen at the University of Tennessee were enrolled in the program (approximately 500 students per year). A new division of the UT College of Engineering called the Engineering Fundamentals Division (EFD) administers the Engage curriculum.

II. DESCRIPTION OF THE ENGAGE PROGRAM

A. Curriculum

Two integrated, team-taught, six credit hour courses in Engineering Fundamentals have been developed under the course designations EF 101 and EF 102. EF 101 concentrates on teaching basic computer programming, graphics skills, and problem solving in the context of a non-calculus based introductory statics and dynamics science component. EF 102 concentrates on teaching calculus-based statics and dynamics. To instill a sense of engineering perspective, both of these courses include regular presentations on current engineering practice. To develop an ability to function as part of a team, the students are divided into groups of five members for the semester. They are assigned team projects that complement the material being taught in the other components of the course.

The basic building block of the curriculum for EF 101 and EF 102 is the instructional cycle. Each cycle involves a one-hour lecture in large classroom format (150 students), taught by the EFD faculty. The lecture presents the new basic mechanics concepts of that cycle. These concepts are then reinforced by a laboratory exercise, where students in small work groups spend an hour developing and demonstrating understanding of the basic concepts. The cycle continues with an analysis and skills session, in which 30 students meet with a team of two graduate teaching assistants. This recitation-style session teaches mathematical, computer, and graphical skills that can help the students apply effectively the concepts they have just learned. The material is integrated around design, build, and test team projects that range from foam-core chairs to rubber band powered vehicles to egg-launching catapults [7]. These team activities introduce students to engineering

design and allow them to experience the same decision-making processes as practicing engineers. The students spend nine hours a week in class for this six credit hour class. In EF 102 the basic cycle concept remains, but more of the recitation time is devoted to team and individual problem solving, instead of to computer skill instruction.

III. NOTABLE CURRICULUM INNOVATIONS

A. Introduction to Design

Design is introduced into the curriculum with team projects that increase in difficulty as the year progresses. The goals are for the students to a) learn that design is a natural process closely related to problem solving skills they already possess, b) experience success as a designer, c) have a positive team learning experience, and d) learn that design success is fun. Students meet three hours weekly in a converted shop for this section of the first year courses. At the start of the first semester they are given a project that requires teamwork, planning, estimating, and knowledge of accuracy and significant figures before any of these topics are discussed formally. The message to the students is that they already know how to solve significant problems, and we are there to show them how to organize their efforts and to teach tools that they can use to increase their problem solving abilities.

Elements of the design method are formally introduced and practiced as the projects become more difficult. For first year students, our experience has been that the appropriate design methodology must be very simple and intuitive and must correlate with problem solving methods they have used before. A specific example is the Pugh chart [8] introduced as a concept selection technique. We introduce this method as a convenient way of assigning numbers and formalizing advantage-disadvantage lists—the same principle they have all used informally for making decisions. For overall methodology, we use a variation on the problem solving methods discussed in Lumsdaine [4] and Fogler [2].

Objectives for the first semester include practice in oral and written report formats, team roles, project planning, appropriate problem specifications, background searching, and idea generation. The final two projects (of four during the first semester) involve constructing a device out of simple materials and testing of the devices. The projects provide real objects to be drawn in graphics and practical examples of the technical material being presented. For example, the design and construction of a foam-core chair complements the discussion of free body diagrams and pre-statics.

For the second semester, only two design problems are attempted, giving the students time to integrate what they have learned about design, and step through the process for each project. Additional requirements that are introduced are the use of concept selection techniques, performing basic experiments on the concepts generated or materials used, and predicting the performance of their device before testing. Matching the technical content of the course, the first project is *static*, typically a structure design where they can perform a predictive truss analysis, and the second project is *dynamic*, where their new knowledge of programming is utilized by requiring a predictive program for a device with changeable inputs. We have used bungee egg drops and catapults

for the dynamics project. Pionke et al. [7] gives a more detailed description of the design program.

B. Physical Homework Laboratory

A physical homework laboratory is an integral part of giving students a thorough understanding of the textbook concepts of physical phenomenon and simple mechanics. The object of this component is to give students a hands-on way of feeling the concept through simple setups where students demonstrate the principles concurrently being taught in the science component of the course. This laboratory experience is described in greater detail by Yoder et al. [10]. This laboratory is deliberately low tech, utilizing weights, levers, pulleys, an air track for frictionless studies, stop-watches and other crude measuring techniques so the students get a feel for how the physical laws are represented in everyday circumstances. The scale of the lab set-ups is such that the students can experience the results with their own senses.

C. Facilitating Freshman Design Teams

At the beginning of our program design efforts, there was great concern about the teamwork skill level of the average entering freshman. It was recognized that teaming and interaction skills must be learned just as analytic skills are taught. A facilitator-training program for engineering students was designed and the curriculum described in detail by Seat et al. [9]. This program is based on having sophomore through senior engineering students work with the freshman teams to facilitate the freshman's adjustment to college life, provide mentoring, and help the team to work together. This closely supervised interaction provides the upper-class engineering students with advanced teamwork and performance skills while exposing all freshmen to a role model.

The facilitator program coursework gives the facilitator-students a theoretical background and applied experience in improving performance in technical task teams. Students receive classroom instruction, have two freshman teams to facilitate, and receive supervision regarding their facilitation performance. Engineering faculty and Ph.D. candidates who have backgrounds in education, counseling psychology, and human services staff the courses.

IV. ASSESSMENT

A. Introduction

Extensive student feedback was gathered through class surveys and focus studies during the pilot year of the program. This data was used to iterate on each aspect of the program and prepare for the second offering, the transition year. The pilot year qualitative data, along with the pilot students' progression data was very positive and was used to obtain final approval to implement the program from the College of Engineering faculty. From this point, our emphasis shifted to gathering data to produce a realistic assessment of some of the measurable effects of the program. The following discussion focuses on data gathered during the two phase-in years that could compare the new program with the traditional program. It was decided that meaningful comparisons could be obtained by comparing Engage students to those in the traditional program in the areas of (a) performance on common exams, (b) performance of students in key courses from the sophomore

year, and (c) graduation rate. This basic data could be easily measured, and represented immediate, short-term, and long-term effects of the new curriculum.

B. Experimental Description

The pilot group of 60 students was chosen by the college to reflect the demographics of the previous year's freshman class. An examination of previous entry demographics suggested that student demographics varied insignificantly from year to year. These students in the pilot program were invited to participate with the option to remain in the traditional program. Almost all the students asked opted to be in the pilot program. The demographics of the pilot group are presented in Table 1.

The control group for the first year consisted of first time freshmen students registered with the College's engineering freshman advising center. There was a requirement that students in the Engage program be enrolled in at least pre-calculus. Due to this requirement, the control group was also restricted to students enrolled in pre-calculus or a more advanced math course.

The second year a group of 150 students was formed to compose the Engage program (termed the transition group). Since this number of students was approximately one-third of the entire freshman class, no attempt was made to balance the demographics of the transition group with the entire class. All freshmen were invited to participate in the transition group as they came to summer orientation until the 150 maximum group size was reached. The demographics of the transition group and the corresponding control group are presented in Table 2. The control group was again composed of first-time freshmen students registered with the college's engineering freshman advising center and who were enrolled in pre-calculus or a later math course.

	<i>Pilot</i>	<i>Control</i>
Total Students	60	254
% Female	20%	20%
% Caucasian	88%	79%
% African Amer.	7%	13%
% Asian	3%	6%
Average Math ACT	27.1	26.2
Average Comp ACT	26.1	25.5
Average HS GPA	3.55	3.43

Table 1. Demographics of pilot and control groups (Year 1).

	<i>Transition</i>	<i>Control</i>
Total Students	150	244
% Female	24%	16%
% Caucasian	79%	87%
% African Amer.	14%	11%
% Asian	4%	1%
Average Math ACT	26.9	26.8
Average Comp ACT	26.2	25.8
Average HS GPA	3.58	3.43

Table 2. Demographics of transition and control groups (Year 2).

C. Student Performance

To compare academic performance between Engage and traditional students, common finals in statics and dynamics were given to both groups in the pilot and transition years. It was not possible to give common finals for the graphics and computer programming courses due to significant differences in the curricular content between Engage and the traditional curriculum. The exams were multiple-choice with up to ten different answers for each problem. Possible answers included results of common errors. These answer choices included errors such as sign errors and incorrect assumptions.

Table 3 summarizes the four groups' performance on the statics final. The *No Errors* entry is the average for all questions of the percent of students who were completely correct on a given problem. The *Common Errors* entry is a similar average for students who made a simple error on the problem that resulted in an incorrect answer. This number mirrors the awarding of partial credit common on engineering exams. In both years, the Engage students did considerably better (an average of 13 percent) than the control students.

Similar results for the dynamics final are presented in Table 4. The Engage students again performed better than traditional students, with an average improvement of 6 percent on this exam.

Another goal of the Engage program was to better prepare students for entry into their respective engineering departments. A measure of this goal was student performance in their first departmental course. This comparison is shown in Table 5. Engage

students outperformed their counterparts with the traditional freshman preparation in every course. All of these positive differences were statistically significant.

D. Student Graduation

One of the goals of the Engage program was to improve graduation rates for engineering freshmen. At the University of Tennessee, the average time to graduation is slightly more than five years, as more than 40 percent of the students are enrolled in a five year co-op program. Generally, six years is necessary to get a complete graduation picture for an entering class. At five years from entering, 43.3 percent of the Engage pilot class has graduated in engineering compared to 25.5 percent of the control group entering at the same time. At four years from entering, 17.9 percent of the Engage transition group has graduated in engineering, compared to 6.1 percent of their control group. Although incomplete, this data is very encouraging as to the long-term effects of the Engage program.

V. CONCLUSION

The Engage program is an innovative curriculum designed to meet the changing needs of freshmen engineering students today. It includes many of the traditional engineering topics but also adds training in design, teaming, communication, engineering perspective, and other skills lacking in some traditional programs. Through integrating the engineering curriculum into two six-hour courses, time is better utilized and provides time and resources to cover these new topics.

The students are shown to be better prepared to succeed academically. The Engage program has succeeded in improving graduation rates in the college of engineering.

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	Fall 1997		Fall 1998	
	Pilot	Control	Transition	Control
<i>No Errors</i>	44	37	50	36
<i>Common Errors</i>	71	57	69	52

Table 3. Performance on common statics final.

	Fall 1997		Fall 1998	
	Pilot	Control	Transition	Control
<i>No Errors</i>	45	37	45	36
<i>Common Errors</i>	65	58	59	60

Table 4. Performance on common dynamics final.

Course	Fall 1997 Freshmen		Fall 1998 Freshmen	
	Engage	Control	Engage	Control
Civil Engr 210	--	--	3.38	3.06
Chem Engr 200	3.50	2.82	3.42	2.75
Elec Engr 201	2.50	2.12	2.73	1.85
Engr Sci 231	3.00	2.72	2.70	2.34
Mech Engr 331	2.79	2.47	2.78	2.32
Indus Engr 202	--	--	3.17	2.75
Matl Sci 201	3.09	2.75	2.66	2.34
Nuc Engr 203	2.88	2.63	3.18	2.74

All differences are significant at 95% confidence level
 -- One Engage student in the course

Table 5. Average course grade in first departmental engineering courses.

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