An "Introduction to Engineering" Course for the Purpose of Student Retention and Recruitment at University of South Alabama

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Abstract

An "Introduction to Engineering" course has been successfully implemented at the University of South Alabama (USA) for the purpose of student retention and recruitment. For retention, based on student enrollment data from Fall 1997 to Fall 1999, 72 out of 90 first-time entering engineering students who took EG 101 (80%) are still enrolled within the college of engineering, compared to 207 out of 338 in the comparison group (61%) who did not take EG 101. The students who have taken EG 101 have a higher average GPA (2.68) than the comparison-group (2.14). For student recruitment, based on student enrollment data from Fall 1997 to Fall 1999, 12 out of 41 high-school seniors who took EG (29%) are enrolled at USA in Fall 1999. These EG 101 high-school seniors who chose to enroll at USA have a higher average enhanced ACT composite score (28) than that of the overall entering first-time student population in engineering at USA (23).

Introduction

An "Introduction to Engineering" course at the University of South Alabama (USA) was implemented in Fall 1997 for the purposes of student retention and recruitment. USA, located in Mobile on the Alabama Gulf-Coast, was created by the Alabama Legislature in 1962 to serve southern Alabama and the neighboring Gulf Coast communities. As a state institution, the entering first-year students come from various academic backgrounds. A measure of the academic preparation of entering first-year students in engineering at USA is the average enhanced ACT score in mathematics, which ranges from 23.2 to 23.6 over the five-year period from 1995-1999.

About one-half of entering first-year engineering students do not meet the requirement to begin the sequence of Calculus courses immediately -- a requirement of at least 27 in ACT math score. These students normally take pre-calculus and humanities/social studies courses during their first year to year-and-a-half at USA and consequently have little or no contact with engineering faculty members and students. Retention of this group of entering first-year students became an objective of EG 101, "Introduction to Engineering."

The College of Engineering has an out-reach program that targets under-represented groups in engineering called ACE (Accepting the Challenge to Excel). Under ACE, four high-school sophomores, selected based on SAT scores from each of Mobile County's 14 high schools, are invited to take part in hands-on activities over 5-6 afternoons in the spring quarter of their sophomore year with faculty members and students from the Mechanical Engineering Department to learn about mechanical engineering. In their junior year, these ACE high-school students interact with faculty members and students from the Chemical, Civil, and Electrical/Computer Engineering Departments during the fall, winter and spring quarters, respectively. If these ACE students are qualified for early-admission to USA when they are seniors, they are offered the opportunity to take an introductory engineering course, EG 101.

Recognizing that USA is a commuter university, the College of Engineering identified as a target for recruitment high-school seniors from the Mobile County Public School System who have a B average and who might find USA's tuition affordable if they are able to stay at home while attending college. High-school seniors who are qualified to enter USA under the early admission policy (ACT composite > 25; a B grade-point average; and recommendations from the high-school counselors) are sent a letter about EG 101 and about their opportunity to take the course tuition-free.

Two sessions of EG 101 were offered beginning Fall 1997: Section 01 is for USA students and for the purpose of student retention, and Section 02 is for high-school seniors and for the purpose of student recruitment. This paper will describe the integration of the Service-Learning pedagogy into EG 101; the learning objectives and the assessment methods; student retention and recruitment results based on student enrollment data from Fall 1997 to Fall 1999; some preliminary results on student learning based on faculty evaluation and on student self-assessment; and reflections by the two instructors.

Service-Learning & Introduction to Engineering

Integrating Service-Learning into "Introduction to Engineering"

EG 101 is similar to many successful "introduction to engineering" courses found in engineering programs in the U.S. that use a hands-on, discovery approach to help students learn problem-solving in engineering and the engineering design process. In EG 101, Service-Learning provides the context for students to learn and practice the engineering design process, teamwork, and communication skills. Service-Learning is "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reflection and reciprocity are key concepts of Service-Learning.... Service-Learning is based on the pedagogical principle that learning and development do not necessarily occur as a result of the experience itself but as a result of a reflective component explicitly designed to foster learning and development. Reflection should include opportunities for participants to receive feedback from those persons being served, as well as from peers and program leaders." [Jacoby, 1996]

At USA, the Service-Learning projects of EG 101 consist of engineering students working in teams to design, produce, and deliver "hardware" and "software" that meet the math- and science-teacher clients' needs and specification to support hands-on learning of math and science in middle schools. Some examples of the deliverables to middle-school math- and science-teacher partners include: an electromagnet that demonstrates the relationships among magnetic field, magnetic force, and electrical current that generates the magnetic field; multi-media packages on the metric units of mass and volume; equipment and activities to demonstrate sound propagation, light propagation, energy and forces of motion; and a web page on a middle-school's constructed wetland project and an instruction manual to teach the middle-school students to maintain and update the web page as the constructed wetland project moves forward. Later, an environmental group, the Dog River Clearwater Revival, was added to the partnership where students designed and produced water sampling devices assembled from parts that are readily available in hardware stores and cost less than $50.

A Service-Learning design project has an advantage over traditional design projects in engineering education (those sponsored by engineering organizations such as the Mini Baja and the ASME Student Design Contest, by industry, or by the faculty instructors). In Service-Learning design projects, students usually have to interact with people who are not from their own socio-economic background and discipline. In the traditional design projects, students interact primarily with other engineers and engineering students. Therefore, in Service-Learning design projects, communication skills and the ability to function in a diverse team take on special meaning. Also, when partnered with middle-school math and science teachers, Service-Learning in engineering is a useful pedagogy to teach engineering design at the 100-level, because there are many examples of engineering described by middle-school mathematics (specifically elementary algebra), so students completing a Service-Learning design project can focus on the creativity and process of engineering design and not feel handicapped by analysis. Service-Learning and K-12 partnership has been successfully demonstrated in a number of “introduction to engineering” programs [Lima, 2000; Lord, 2000; Tsang, 2000].

Learning Objectives and Assessment Methods

The Learning Objectives for EG 101 are:

Objective 1. Students demonstrate an understanding of the engineering design process by completing a Service-Learning design project.

Each student design team is required to submit a written report, which is evaluated by the course instructor, and make an oral presentation that is evaluated by another engineering faculty other than the course instructor. Evaluations by two different faculty members provide some “objectivity” when evaluating engineering design projects.

Students complete a Post Survey that has two questions testing their knowledge on the steps of engineering design process -- see Appendix I.

Objective 2. Students practice and demonstrate teamwork

The process of teamwork is tracked by the minutes of team meetings that students submit regularly, which allow the faculty instructor to monitor team dynamics and the progress of the design project. Student attitudes about teamwork are surveyed in the Post Survey -- see Appendix I

Objective 3. Students demonstrate basic competencies with a spreadsheet program

Both formative and summative evaluations are done in the course. Final evaluation is based on self-assessment by students in the Post-Survey done at the completion of the design project -- see Appendix I.

Objective 4. Students self-reported attitude about community service will improve

Student attitudes about community service are surveyed in the Post-Survey -- see Appendix I.

In addition, students also complete a short Pre-Survey, which allows the instructor to address any concerns raised by the students about the design project and to compare the student responses in the Pre- and Post-Survey for additional information about student learning.

Some Preliminary Results

EG 101 is not a required course for USA students; students can only be advised by their academic advisors to take the course. Furthermore, many engineering faculty members at USA are hesitant about advising a student to take a course that is not on the curriculum. The number of students who have taken EG 101 over the period from Fall 1997 to Fall 1999 is relatively small -- 90 USA students and 41 high-school seniors. Because of the small sample size, the results must be interpreted with caution.

Retention Results

The comparison group is entering first-year students in engineering who did not take EG 101. Based on student enrollment data from Fall 1997 to Fall 1999, the results of retention effort of EG 101 are summarized in Table 1. Overall, 72 out of 90 first-time entering engineering students who have taken EG 101 (80%) are still enrolled within the college of engineering, compared to 207 out of 338 in the comparison group (61%). The students who have taken EG 101 have a higher average Grade Point Average (GPA) than the comparison-group students -- 2.68 versus 2.14. Focusing on the female sub-population, 27 out of 32 (84.4%) students who have taken EG 101 are still enrolled in engineering, compares with 47 out of 83 (56.6%) who have not taken EG 101. Female students who have taken EG 101 have a higher average GPA than female students in the comparison group -- 2.87 versus 2.14.

Recruitment Results

The comparison group consists of early-admission high-school seniors who declared engineering but did not take EG 101. The result of the recruitment efforts of EG 101, based on student enrollment data, is summarized in Table 2. Overall, the recruitment success rate among high-school seniors who took EG 101 is 29% (12 out of 41). It is noteworthy that five of the 12 recruited students are female (41.7%), which represent a higher percentage of female students than in the overall entering first-time student population (27%). Furthermore, the 12 students who took EG 101 and attended engineering again have a higher average enhanced ACT composite score (28) than that of the overall entering first-time student population in engineering (23). Of the five female EG 101 students who are still in engineering, they have an average enhanced ACT composite of 27.8.

Preliminary Results from Post Survey

Understanding of the Engineering Design Process

Data from Post-Survey suggests that students do see value in doing the project. Particularly relevant to the students are issues of meeting customer satisfaction, working with constraints, and developing the ability to work as a team. When students indicated that the project was not clearly relevant, they often cited the area of engineering they were interested in as different from the project content area. However, even these students felt that the project helped them with the client and team skills noted above. Also, students were much more likely to list engineering design process and problem solving after they have finished the project in the post survey.

Students Practice and Demonstrate Teamwork

Students had mixed feelings about working in groups. Most enjoyed the process and felt they had learned more, but there were some concerns over students not pulling their share of the load. These concerns are not uncommon, and we try to address them by training students to work in groups, putting in grade incentives for individuals to participate, and having the instructors meet with the groups to help keep them on task. We use the report by Bellamy *et al* [Bellemy 1996], *Teams in Engineering Education*, as the course materials for teamwork training.

Course materials

Students Practice and Demonstrate Teamwork

Data addressing the spreadsheet items indicated that students were moving toward competency in many of the spreadsheet skills. Either they had them prior to the class or developed them within the context of the class. Data on the first eight items on spreadsheet knowledge indicated that all items except for one had medians of 8 or greater. The one that was less than 8 had a median of 7.5. With a score of 10 indicating fluency in carrying out these spreadsheet tasks, it seems clear that students have or are moving toward spreadsheet fluency.

Improvement of Attitudes Toward Community Service

In general, attitudes were positive toward community service, but for the most part, there was little attitude change. Most of the students viewed community service as an important part of the professional identity of engineers.

Instructor Reflections

Reflections of Edmund Tsang

I have taught Section 01 (for USA entering first-year students) two times and Section 02 (for high-school seniors) four times. A common feature of the two sessions of EG 101 are the use of case studies requiring only simple algebra to illustrate engineering problem-solving and design, so a majority of the students would have the mathematics knowledge-base, because they either have taken or are taking a course on introductory algebra. Other common features of the two sessions include materials on teamwork, communication and computer skills, and on a survey of the engineering profession and disciplines. There are, however, some differences: For Section 01, more emphasis is placed on student development using materials from *Studying Engineering: A Road Map to a Rewarding Career* by Ray Landis [Landis, 1995]. Also, more time is devoted in Section 01 to some of the case studies. For Section 02, the pace is accelerated to include two additional cases.

I observed that while a majority of Section 01 students may lag behind Section 02 students in math and science content knowledge, the extra few years of life experience of the Section 01 student served them well in carrying out the service-learning design projects by giving practicality to their design ideas. For Section 01 students, more emphasis in the class is devoted to professional personal development in such traits as commitment, timeliness, and perseverance. In general, Section 01 students need more help from the instructor in compleing the computer spreadsheet assignments.

It is not possible to state that Service-Learning is responsible for the success of EG 101 in student retention. Nevertheless, I believe the combination of Service-Learning and partnership with K-12 provides an excellent context for the targeted students to develop problem-solving skills that will serve them well in other courses they take, including pre-calculus or algebra.

Reflections of Robert Foley

I have predominantly been associated with Section 01 for first year engineering students since the Fall of 1997 having taught EG 101 a total of six times. Since the students in this section typically lack the prerequisite math and science for rigorous engineering material my focus has been on students developing a thorough understanding of the engineering educational process, engineering careers and the strategies necessary to be successful as an engineering student. Ray Landis' text *Studying Engineering: A Road Map to a Rewarding Career* has provided excellent reference information to assist students in creating a path for success based on factual knowledge of the engineering profession that allows them to set realistic and attainable goals for themselves.

Case studies are used extensively to relate the importance of computers, teamwork and communications in engineering problem solving. Students work together on case studies learning the proper mechanics of team problem solving and then each team is given opportunities to write engineering style reports and give oral project presentations. The importance of report quality and application of presentation software is emphasized.

Later in the course, service learning projects have provided the ideal platform for students to apply elements of the engineering design process and while developing skills required in the engineering profession. Specification development, customer requirements, continuous improvement and cost/benefit analysis, for instance, are typical considerations for each interdisciplinary project. Students develop confidence and experience the excitement of the engineering problem solving process. Of course, the real success is clearly that a group of students that may have spent their first year relatively detached from the engineering educational community have already initiated their engineering maturation process. I have often observed students that have completed EG 101 to be comfortable in the presence of upper division students and with faculty. This is manifest by these students readily seeking advice, participating in student professional activities, entering into strong mentoring relationships and taking leadership roles on student projects.

Appendix I

Post-Surveys

1. You have recently completed a design project involving work either with a school teacher to design equipment that can be used in science education, or with a community organization to solve an environmental or other societal problem. How relevant(irrelevant) do you think the project you have completed is to your training as engineer? What made it relevant(irrelevant)

2. What tools and skills did you acquire in the EG 101 course that helped you to complete the project? Specify what they were and how they helped you.

3. What concerns did you have about the project that made you anxious? Specify your concerns and why they made you anxious. Were your concerns addressed?

4. What aspects of the project were most enjoyable? What made them enjoyable?

Part I. Engineering Design Process

1. List in order the steps in the engineering design process.

2. Explain how you carried out each step of the design process in your project.

Part II. Computer Spreadsheet

The following are a list of spreadsheet skills you may have acquired during the course. Indicate 1 (not at all) to 10 (can execute fluently) scale in answering each question. Fluent execution means you can go through the steps to carry it out without searching through menus, asking for help, or using help functions. Put answers to these items on this sheet.

1. Enter data into cells _____

2. Create a table that is formatted for presentation ______

3. Construct a formula involving various arithmetic and trigonometry operations and exponentiation ____

4. Cut and paste values or formulae _____

5. Use built in mathematical and statistical functions _____

6. Replicate formulae so they can be applied to data in different rows or columns _____

7. Construct a bar graph, line graph, or pie chart with the spreadsheet _____

8. Customize the graph or chart to meet specific needs _____

9. Embed graphs/tables into other softwares such as word processing software _____

10. Your knowledge of spreadsheet prior to EG 101 ______

Part III. Teamwork

1. You did your project as a team.

a) What was the best part of working on the project as a team?

b) What was the worst part of working as a team?

2. How did your team get along?

3. Did people carry out their assignments?

4. How relevant is doing work in teams to engineering?

5. If you had a choice, would you rather do the project working with a team or by yourself?

Part VI. Attitudes on Community Service

How has your experience with the project changed your ideas about community service? If it has changed your ideas, explain how. If it has not changed your ideas, why not?

Pre-Survey

EG 101 students also complete a pre-survey handed out after they have been assigned the Service-Learning design projects in mid-semester. The questions in the pre-survey are:

1. You are about to begin a design project that either benefits the environment or education of Mobile's students. How relevant (irrelevant) do you think the project is to your training as an engineer? What makes it relevant (irrelevant)?

2. What tools and skills have you acquired so far that will help you to complete the project? Specify what they are and how they will help you.

3. What concerns do you have about the project that make you anxious? Specify your concerns and why they make you anxious.

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Table 1. Retention Results of EG 101 for First-Time Entering Engineering Freshman

Year	Students	Took EG 101	Still In Engr.	Avg. GPA
97-98	All	Yes	10/15 (66.7%)	3.04
		No	85/151 (56.3%)	2.29
	Female	Yes	2/2 (100%)	2.52
		No	19/38 (50%)	2.00
98-99	All	Yes	42/52 (80.8)	2.63
		No	75/112 (67%)	1.95
	Female	Yes	16/18 (88.9%)	2.97
		No	16/29 (55.2%)	2.03
Fall 99	All	Yes	20/23 (87%)	2.61
		No	47/75 (62.7%)	2.16
	Female	Yes	9/12 (75%)	2.77
		No	12/16 (75%)	2.51
Overall	All	Yes	72/90 (80%)	2.68
		No	207/338 (61%)	2.14
	Female	Yes	27/32 (84.4%)	2.87
		No	47/83 (56.6%)	2.14

Table 2. Recruitment Results of EG 101 for Early Admission High-School Seniors

Year	Took EG 101	Attended Engineering Again
97-98	Yes	4/9 (44.4%)
	No	5/15 (33.3%)
98-99	Yes	6/22 (27.3%)
	No	0/1 (0%)
Fall 99	Yes	2/10 (20%)
	No	0/3 (0%)

The column "Attended Engineering Again" represents those students who attended engineering again after taking either EG 101 or another course at USA previously.

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Robert Foley

Robert Foley is the Assistant Dean of Engineering at the University of South Alabama. His current interests include developing workforce enhancement and manufacturing improvement programs based on advanced engineering applications and university-industry partnerships. He is extensively involved in research related to High Speed Sealift Shipbuilding Technology. His previous government service included management of aeronautical engineering programs and multi-million dollar major systems acquisition projects. He is a Senior Fellow of the Council for Excellence in Government and his honors include the U.S. Secretary of Transportation Team Award, and the U.S. Legion of Merit. He received his M.S. in Aeronautical Engineering from Purdue University in 1981 and a B.S. from the U.S. Coast Guard Academy in 1971.

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