2006-1569: A PROGRAM TO IMPROVE LEARNING AND RETENTION OF FIRST YEAR ENGINEERING STUDENTS

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A Program to Improve Learning and Retention of First Year Engineering Students

Abstract

Analysis of retention data in engineering programs at the Pacific School of Engineering and Computer Science revealed that only 45 to 50 percent of students entering as freshmen actually graduated from engineering programs in 2003 and 2004, and that up to 30 percent had left during their first year. A new program implemented in Fall 2005 is focused on improving retention of, and the quality of learning by first year engineering students. The program has been integrated within the context of the core "Introduction to Engineering" course taken by all engineering majors, leveraging the small school environment found at Pacific. Program components include a peer mentoring/tutoring program, math assessment tests, informal gatherings and guest speakers, field trips, and support of student chapters of professional engineering organizations' activities that promote student participation. The main component of the program is the peer mentoring/tutoring program. Sixteen students, ranging from sophomores to seniors, each serve as mentors to six to eight first year students. First year students are required to meet with their mentor for special review of engineering and math assignments, development of curriculum plans and time management plans, among other tasks. Specific attention is being given to students from populations traditionally underrepresented in engineering. The overarching objective of the program is to not only familiarize first year students with the engineering discipline but also to integrate them into the School quickly.

Program effectiveness will be measured with a set of outcome indicators, most notably retention, but also including other factors such as performance on assessment tests, performance in subsequent courses, and eventually, graduation rates. Outcome indicator data will be compared to statistics from the past three to five years. Preliminary results of this on-going program will be presented at the conference.

Introduction

At many universities, 50 percent or more of entering first year students drop out of engineering due to a slew of reasons, many engineering schools are trying to identify and remedy. With fewer students entering engineering programs[1], greater effort and attention must be allocated to retaining students who have decided to pursue an engineering education. The following have been given as primary reasons for the high attrition rate[2]:

1. Students are frustrated by the fact that while they almost effortlessly passed their classes in high school, they earn significantly lower grades (even C's and D's) while working substantially harder in their first year college courses. Additionally, engineering students find themselves working much harder than their peers in other majors.

2. The transition from the controlled environment in high school to the independence gained in college leaves many unprepared and with a lack of direction regarding study habits and time management skills.

3. Inadequate preparation in science and mathematics during high school often leaves first year students struggling through the calculus and physics series. Physics, mathematics, chemistry, and other core courses, mainly taught by non-engineering professors, fail to convey the excitement of, or relevance to, engineering.

Preliminary analysis of retention data in engineering programs at Pacific showed that only 50 to 55 percent of students entering as freshmen actually graduated in engineering in May 2003, 2004, and 2005. Up to 30 percent left during their first year and approximately 15 percent left during their second year. A study of retention at the University of Maryland, Baltimore County (UMBC)[3] comparing retention rates of Science, Technology, Engineering, and Mathematics (STEM) students with those at other highly selective institutions found 57 and 65 percent 6-year graduation rates at UMBC and at the other institutions, respectively, during the period 1995 to 1998. Six-year graduation rates of under-represented minorities (African-American, Hispanic, Native Americans) were markedly lower at the highly selective institutions, ranging from 31 to 34 percent [4]. In 2002, women earned 20.5 percent of the engineering baccalaureate degrees awarded, and underrepresented minorities earned 11.6 percent of engineering degrees awarded[5]. However, despite overall progress in increasing numbers of students entering engineering, the proportion of women and underrepresented minorities entering as engineering freshmen has declined since 1995[5].

Examination of results presented in a nationwide study of retention from 1980-81 to 1989-90 revealed that 36 percent of engineering freshmen from underrepresented minority groups were retained to graduation, compared to 68 percent of non-minority freshmen[6]. For those students who persisted in engineering to the sophomore level, 67 percent of underrepresented minorities and 87 percent of non-minorities persisted to graduation. Other studies have focused on academic and environmental variables affecting student retention and performance [7,8]. These results confirm observations at the University of the Pacific, that the highest rate of attrition occurs during the first year, decreasing during subsequent years. Specific programs focusing on undergraduate retention have been shown to improve retention rates, particularly among women and underrepresented minorities [2,9]. Elements of successful programs have included academic support, social support and integration, support for engineering societies, scholarships, and summer "bridge" or other preparatory programs.

To address the retention problem at Pacific, a multi-faceted program was implemented in Fall 2005 focused on improving retention of, and the quality of learning by, first year engineering students. The program was integrated within the context of the core "Introduction to Engineering" course taken by all engineering majors and was designed to leverage the small-school environment at the university, and enabling freshmen to develop closer ties with faculty and with students from different years. Program components include a peer mentoring/tutoring program, math assessment tests, informal gatherings and guest speakers, field trips, and support of student chapters of professional engineering organizations' activities that promote student participation. The overarching objective of the program is to not only familiarize first year students with the engineering discipline but also to integrate them into the School quickly.

Components of the Retention Program at Pacific

The first year engineering class at Pacific has ranged in size from 100 to 130 students during the past five years. All first year engineering students take Introduction to Engineering (ENGR5), a course designed to introduce students to the different fields of engineering. Responsibility for teaching this core course is shared by all engineering departments within the School of Engineering and Computer Science (SOECS) and the course is co-taught by five faculty of all ranks and from different departments. The course allows faculty to develop close relationships with incoming students at an early stage. Two of the faculty who helped developed this retention program were also responsible for teaching ENGR5. Program components were integrated as part of ENGR5 and subsequent courses typically taken by first year engineering students, and are described below.

1. Peer-to-Peer Mentoring Program

The main component of the program is the peer mentoring/tutoring program. Sixteen students, ranging from sophomores to seniors, were selected to serve as mentors. The mentors were selected principally based upon academic major, academic record, and past tutoring, mentoring, or leadership experience. The applicants, and thus the mentors selected, formed a diverse group: five of sixteen mentors were women, and seven of sixteen were from under-represented minority groups.

Each mentor was assigned six to eight freshmen, paired by major, then if possible, by gender or ethnicity. Freshmen were required to meet with their mentor for special review of engineering and math assignments, development of curriculum plans and time management plans, among other tasks required for ENGR5. Meetings with mentors and obtaining the mentor's signature were specified as required components of most ENGR5 course assignments. Mentors held "office hours" on weeknights in the main Engineering building and provided tutoring for courses, assistance with ENGR5 assignments, discussed campus life, provided guidance on engineering programs, study skills, and so on. Mentors were required to keep a log of meeting times and topics and to track their students' progress throughout the semester.

Program faculty met with the mentors at the start of the term for an orientation and at the end of the semester for assessment purposes. Mentors also met frequently with the program faculty during the Fall term, particularly in cases where concerns arose. Communication and frequent contact among the mentors and program faculty was facilitated by the small-school environment at Pacific: most mentors were enrolled in one or more courses taught by the program faculty, served as engineering society officers for which the faculty served as advisors, or assisted with research related to retention.

2. Math Skills Assessment Tests

A basic math skills assessment test was developed and administered in the ENGR5 class at the start of the Fall semester and again at the end of the semester to help the instructors and students assess their fundamental skills. Topics covered on the test included algebra, geometry, trigonometry, logarithms, and fundamental graphing. Review of students' performance on the

assessment test revealed that forty percent of the students scored below 65%. Consequently, math assignments were developed to improve their skills in this area, and additional course time was dedicated to trigonometry when introducing vectors.

3. Field Trips

Eight field trips were organized during the Fall semester to companies and sites related to the practice of engineering. Each student enrolled in ENGR5 was required to attend at least one field trip. Field trip sites were selected to showcase the different engineering disciplines and their linkages, and to allow students and faculty to interact in an informal setting. Sites visited included Gallo Winery, General Mills, the Port of Stockton, and Intel corporation.

4. Support of Student Chapters of Professional Engineering Societies

Student chapters of professional engineering societies can play an important role in student education by developing students' design, professional, leadership, and teamwork skills. These chapters also play an important role in retention by integrating students into the academic community and by providing them with a real-world perspective on their selected major. Each organization was invited to submit a proposal for increasing student involvement in that organization (particularly freshmen) and for enhancing students' education and professional development. Organizations were allocated amounts up to $500 which have been used for field trips, speakers, competitions, papers, and social activities focused on increasing participation in the organization. All chapters submitted a report of activities and documented participation in the events during the term. The level of participation will be compared to that of previous years.

An all-SOECS Fall Welcome barbecue was co-hosted by student chapters at the start of the semester. All freshmen were invited to attend and mentors were required to attend and to meet their assigned students. Each student chapter set up a table with posters, photographs, and information about the chapter activities; officers and other chapter members were available to greet interested students and answer questions. Student organizations reported increased participation and involvement, especially by freshmen, as a result of the event.

5. Supplemental Instruction

During the Spring semester, there is no single course that will facilitate contact with all freshmen at the same time as ENGR5 did during the Fall semester. Therefore, mentors will serve as "Supplemental Instructors" for a range of courses in which engineering freshmen are enrolled including various Calculus, Physics, and Biology courses. As part of their responsibilities, mentors will attend the course lectures, hold office hours, tutoring sessions and will facilitate study sessions each week. Benefits of this approach, although voluntary on the part of freshmen, is that the freshmen will have opportunities for sustained contact with one or more of the mentors throughout the semester and direct access to a peer mentor/tutor with whom they are already familiar and feel comfortable approaching.

Program Assessment and Future Directions

Program effectiveness is assessed on an on-going basis by the program faculty via meetings with freshmen, mentors, and other faculty in charge of freshman courses. Measures of program effectiveness will include retention statistics, performance on assessment tests, performance in subsequent courses, and eventually, graduation rates. Assessment of first-semester retention will be made during the Spring term by comparison of SOECS enrollment lists to the Fall 2005 ENGR5 course roster. Retention will also be examined upon completion of the Spring 2006 semester based on pre-registration rosters, and outcome indicator data will be compared to statistics from the past three to five years. Preliminary results of this on-going program will be presented at the 2006 ASEE conference. It is anticipated that modifications will be made to the program for the next academic year based on analysis of retention and performance statistics from 2005-06.

Several survey instruments were developed as part of this program, including feedback surveys for freshmen and mentors. Comments from mentors and freshmen revealed strengths of the mentoring program and areas in need of improvement. Freshmen noted that the primary strengths of the program were that it provided them with opportunities for receiving focused one-on-one help and with the ability to have their work checked by the mentors. They also noted that mentors helped motivate them about the engineering field, provided insight about future courses and directions, and helped them with time management skills. 40 percent of the freshmen agreed that the mentors clarified or strengthened their decision to stay in or leave Engineering, and 60 percent stated that the mentors had no impact on their decision. Mentors believed that strengths of the program included increased communication and camaraderie among students from different classes and majors, as most mentors met in a single common location. The mentors noted reduced frustration on the part of the freshmen who were able to receive extra help for courses, increased awareness of the need to develop effective study habits and time management skills, and enhanced awareness regarding time requirements in engineering compared to other majors. Mentors also noted improvement in their own study skills, communication skills, and in their understanding of the various subjects in which they tutored their students.

Program logistics and access to freshmen were noted as the two main areas in need of improvement. In many cases, scheduling conflicts prevented students from meeting their mentors. Surprisingly, while many freshmen resented being required to see their mentors for help on assignments, the mentors conversely felt that they did not have enough contact with their students! Student and mentor responses will be solicited at the end of the Spring 2006 semester, for comparison of contact frequency and quality when the mentors serve as Supplemental Instructors. If the program funding is renewed for the 2006-07 academic year, new avenues will be sought to enhance and promote contact between mentors and freshmen.

A preliminary study of retention trends is currently being conducted by the program faculty to identify possible factors causing students to leave the engineering program at Pacific. The study will be conducted in large part during summer 2006 to include statistics on multiple Calculus and Physics courses. Factors being evaluated include grades in Calculus, Physics, and fundamental engineering courses. Together with information gathered from an exit survey given to students who change to non-engineering majors, these data will serve as a baseline for assessing the effect

of the proposed program on retention and performance (GPA and other measures) at successive semesters.

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