A Retention Study at Baylor University

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Abstract

Faced with an engineering program graduation rate of approximately 22%, Baylor University's Department of Engineering recognized the need to identify factors influencing student attrition from engineering. By attracting new students and retaining current engineering students, Baylor University's engineering program has improved this graduation rate in the recent past to approximately 30% but this is still below the national average of 38%. The engineering program at Baylor University is a small, undergraduate only program with a strong emphasis on teaching and student/faculty interaction. Retention statistics for the program are presented and compared with the literature. The work and results from the School of Engineering and Computer Science Retention Committee is reported. The committee explored risk factors contributing to the loss of students. The freshman course sequence is also presented. One outgrowth of this study was the creation of a Freshman Success Task Force, which is charged with generating "a plan and process to increase the success/persistence of freshman computer science and engineering students at Baylor." The retention goals set by the Task Force are discussed and the resulting curriculum initiatives presented. Of note is the participation of Baylor University's Information Management and Testing group, which helped identify capabilities and limitations associated with institutional data collection/management and started the search for relevant data analysis and collection instruments.

Background

The engineering program at Baylor University began in 1979 when a faculty committee, at the direction of the University President, created an engineering science curriculum and hired the first engineering faculty member. The engineering science program developed three options targeted to electrical, mechanical, and computer engineering. As more faculty were added, the engineering science program was modified to conform to specific ABET accreditation criteria, however, the ABET criteria forced Baylor to seek accreditation under the non-traditional criteria since Baylor did not meet minimum faculty counts. The initial ABET visit did not proceed well and a second visit was requested. Between the first and second visit, the three options were reduced to two, mechanical and electrical, and a common engineering core was created for a general engineering program with options. The second visit resulted in the initial accreditation for the Engineering program.

As the engineering program matured, the students that entered Baylor University to study engineering, for the most part, were first attracted to Baylor by its reputation as a private, church related institution and secondarily for engineering. From the mid 80's to the end of the 90's the program was stable with a small growth rate. In 1995, the engineering program, previously a department within the liberal arts college, was organized as the School of Engineering and Computer Science. With the higher visibility came pressures for growth and expansion of the engineering programs. Starting in 1999, the Engineering Department developed two new engineering programs Mechanical Engineering and Electrical and Computer Engineering and significantly restructured the existing Engineering program to allow pre-professional combinations. All three programs were accredited in 2001. The addition of two new programs was squarely aimed at increasing Baylor's visibility in engineering and placing it on a growth track. Program growth was sought in two directions; first, attract larger numbers of well-qualified students and, second, increase student retention rates to preserve the front-end recruiting efforts.

Retention Taskforce

A taskforce to study the retention rate in the School was initiated by the Dean in the fall of 2000[1]. The Associate Director of Information Management and Testing at Baylor University chaired the group. The other members included the Coordinator of Student Retention and two faculty members from the School of Engineering and Computer Science. The mission of the study group was to collect factual data, arrange for subjective information such as focus groups, solicit input from constituents, consider proven strategies, and examine other information as appropriate and needed. Further, the committee was told it could investigate deeper specific problem areas and areas of opportunity.

The questions the group was to address included:

- What is the retention rate for engineering and computer science?
- What are the factors leading to the poor performance of some students, and to the selection of another major for students performing well?
- What are the opportunities and strategies to significantly improve the school's retention rate?

Engineering Retention Rate

Retention data for engineering (all disciplines) were collected for a six-year period. Retention rates from course to course were evaluated, as well as overall engineering graduation rates. The following table contains retention and graduation statistics for students in engineering. The courses shown in Table 1 were selected to track student progress since all engineering students took these courses, regardless of engineering discipline. Each cohort group is defined as those

students who took the first engineering course in the fall or spring semester of a particular academic year. These students were then tracked throughout their career at Baylor.

Table 1. Department of Engineering Retention Data

	EGR 1301[1]	EGR 1302[2]	EGR 2430[3]	EGR 3380[4]	Engineering Degree from Baylor	Any Degree from Baylor
Fall 94 / Spring 95	81	60.5%	29.6%	21.0%	21.0%	64.2%
Fall 95 / Spring 96	73	67.1%	37.0%	27.4%	23.3%	63.0%
Fall 96 / Spring 97	85	83.5%	55.3%	40.0%	32.9%	64.7%
Fall 97 / Spring 98	85	74.1%	56.5%	45.9%	31.8%	50.6%
Fall 98 / Spring 99	125	70.4%	48.0%	35.2%		
Fall 99 / Spring 00	85	65.9%	44.7%	38.8%		
Fall 00 / Spring 01	94	75.5%	46.8%	28.7%		
Fall 01 / Spring 02	104	62.5%				

1 EGR 1301 is "Introduction to Engineering" usually taken fall freshman year
2 EGR 1302 is "Introduction to Engineering Fundamentals" usually taken spring freshman year
3 EGR 2430 is "Electrical Circuit Theory" usually taken spring sophomore year
4 EGR 3380 is "Engineering Design I" usually taken fall junior year

The first data column, labeled "EGR 1301", shows the number of students enrolled during an academic year. The second column, labeled "EGR 1302", shows the percentage of students from EGR 1301 who subsequently took EGR 1302. The third column, labeled "EGR 2430', shows the percentage of students who then subsequently took EGR 2430. The fourth column, labeled "EGR 3380", shows the percentage of students who then took EGR 3380. The fifth column shows the resulting graduation rates for the students who enrolled in EGR 1301 and graduated with an engineering degree from Baylor University.

The data analyzed show an overall graduation rate of about 22.1% for the first two groups studied. The next two groups show graduation rates of approximately 32.3%. For comparison, the Higher Education Data Sharing (HEDS) Consortium, a group of private universities that share data, show the average five-year graduation rate for students entering and graduating in engineering is 42.0%. The 1999-2000 SMET Retention Report contains the retention and graduation rates of 1992-98 entering science, mathematics, engineering, and technology majors in 119 colleges and universities. The study showed that the average six-year graduation rate for the SMET majors from a SMET discipline was 38%. This puts Baylor University's current engineering graduation rate approximately 75% of the national average.

Engineering Risk Factors

The next part of the study sought to determine the risk factors for students enrolling in engineering. The risk factors were examined from three perspectives: faculty, students, and curriculum; each being a source of the potential risks. The following is a summary of the risk factors for each of these perspectives.

Faculty

The primary risk factor for engineering retention that affects the faculty was workload. To accomplish the important, necessary tasks for teaching was not possible, given the number of engineering faculty employed. Faculty were required to carry 12 semester hours of class and 12 office hours each semester. With required laboratories, the student contact hours increased even more. At the time of the study, the department had ten full time faculty members. Of the ten, one was the department chair and another was the associate dean both of which had the commensurate administrative duties further increasing faculty workload. Some of the areas affected include:

- Assessment – assessment tools are not utilized as they should be, and even when utilized there is rarely time to adequately analyze the data
- Student Interaction – because of the workload of the faculty, adequate time for student interaction is not available (office hours, outside student activities, advising, etc.)
- Research – research time, especially for new tenure-track faculty members, is inadequate
- Professional Development – again, because of workload, the faculty are rarely able to take advantage of professional development opportunities
- Course Development/Enrichment – no dedicated time to develop new courses or improve existing courses

Students

The risk factors for engineering retention that pertain to students include:

- Inadequate preparation prior to matriculation
- Lack of pre-screening of engineering students
- Upper division admission process may allow marginal students to continue in the program (At Baylor, students may declare engineering as early as entry into the university. Engineering students, however, are not "admitted" to the upper division of the engineering program until they have finished a certain number of science, math, and engineering courses, and have maintained a minimum grade point average. This assessment is not usually performed until sometime toward the end of the sophomore or beginning of the junior year.)
- Students' perceptions of "hard" versus "easy" professors

- Poor competitive learning strategies

Curriculum

Risk factors for engineering retention that pertain to the curriculum include:

- Lack of continuity between the first two freshman engineering courses (these courses were initially developed to be motivational and help with student retention, but have diverged somewhat in time)
- Curriculum changes have confused students
- Not enough writing opportunities in the curriculum
- Department decline in US News and World Report national engineering program rankings for undergraduate only institutions

Engineering Retention Study Recommendations

Most of the recommendations from the Study Group follow logically from the risk factors. Faculty additions were needed to spread the workload around. This would keep classes small and give faculty time for assessment, student interaction and involvement, research, professional development, and course development/enrichment. Since the study was completed, four additional tenure track faculty and three part time faculty have been hired to reduce teaching loads to six semester hours each semester. However, increased research pressures are absorbing much of the available time for other activities.

Students need to be screened for engineering earlier in their college career to allow time for changes and to minimize wasted resources. Students who perform poorly should be counseled immediately (students with a deficient grade currently have an automatic second chance to take the course again . After a deficient grade in their second attempt they can be placed on probation, thereby prolonging their participation in the program when they may not be suited to engineering.). The School of Engineering and Computer Science should work with the Student Success Center to develop specific intervention programs for at-risk engineering students.

The curriculum should be studied further to determine where continuity could be improved from course to course. The department should place faculty who are stronger in teaching and student interaction in the early courses, to further encourage student retention. The conditions for admission to the engineering program should be studied so that exceptions are minimized.

Other recommendations include:

- Do a continuation of this study to investigate the “Freshman Experience” and how Baylor might take advantage of other things that would increase student success

- Investigate how the School's national rankings can be improved (what are the criteria upon which this assessment is made?)
- Investigate the link between secondary education quartile ranking and the successful completion and the engineering program. This is may be a good predictor of success.

Many of these recommendations are being investigated further. The School of Engineering and Computer Science convened a Freshman Success Task Force to continue this study of the "Freshman Experience" and to study how to increase overall student retention. The study focused on the introductory freshman course sequence and external grants to enhance the engineering program, such as the Texas Technology Workforce Development Grant Program, which will be addressed later in the paper.

Retention Focus - Introductory Freshman Course Sequence

A key element of freshman engineering retention effort is associated with the introductory freshman course sequence taken by all engineering students. The courses are EGR 1301, *Introduction to Engineering*, and EGR 1302, *Introduction to Engineering Fundamentals*. A more complete description of these two courses can be found in Van Treuren and DeJong (2001)[2]. These courses are a student's first encounter with both the profession of engineering and the Department of Engineering.

EGR 1301 Introduction to Engineering

The department, since its inception, has always had a course for freshmen in its curriculum taught in the first semester. At first, the freshman engineering course was a manual drafting course required only of mechanical engineering students. There was concern on the part of the department chair that student retention should be improved and that all incoming freshmen engineering students should have the experience of an introductory engineering course. In the fall of 1986, the course was approved and implemented. The course description was as follows:

> EGR 1301: Introduction to Engineering Analysis and Design Techniques. Practice in solving engineering problems. Introduction to engineering graphics and the use of computer work stations. (2-3)

This course was to follow a two-hour lecture and a three-hour lab format. The objectives of the course were as follows:

1. To introduce the engineering profession and its challenges.
2. To motivate freshman engineering students in their study of science and mathematics.
3. To develop some basic tools of engineering including graphical skills, presentation of engineering results, use of hand-held calculators, engineering applications of microcomputers, design process and systems of units.

4. To introduce several technical subjects engineering students will encounter in their educational program.
5. To provide opportunities for group design experience.

The course was designed to motivate students to make an early commitment to engineering as a career choice. Departmental records are incomplete and it is not possible to determine whether retention improved as a result of the addition of this course.

Through the years the course purpose remained essentially the same, to help students decide on their future in engineering. Changes in course content were introduced to reflect the increasing need for students to learn the skills and tools necessary for a successful professional and academic career. Emphasis was placed on teamwork and communication using a team-based design project as a pedagogic vehicle. More information on the design project is available in DeJong, et al. (2000)[3].

In 1999, the course description was changed to more accurately describe the intent of the course.

> EGR 1301: Introduction to Engineering. Introduction to the Engineering Profession. Topics include engineering disciplines, ethics, the impact of technology on the world, analysis and design using a team project, and computer aided design and problem solving. (2-3)

Much of the new focus incorporated into the course was influenced by the ABET 2000 criteria, thereby the course goals changed as follows:

1. To provide career guidance and motivation for new engineering students.
2. To provide a sense of community among engineering students and faculty.
3. To provide students with experience in engineering problem solving.
4. To develop some basic analytical and design skills needed by engineers.
5. To introduce drafting and Computer Aided Design.
6. To develop basic engineering computer skills (i.e. spreadsheets, word processing, etc.)

EGR 1302 Introduction to Engineering Fundamentals

With the perceived success of EGR 1301, in spring 1993 another freshman engineering course was introduced. This course was added to help students better decide whether engineering is a viable major for them by providing an introduction to fundamental aspects of engineering systems and how engineers approach solving problems in those areas. This course was also to assist in student retention by providing direct contact with freshman students in their second semester of course work. EGR 1301 was a prerequisite course and the course was originally a three-hour lecture course. The original catalog course description was as follows:

> EGR 1302 Introduction to Engineering Fundamentals – Introduction to fundamental problem solving techniques in engineering analyses of Mechanical Systems, Electrical Systems, Computer Systems, and Energy Systems. (3-0)

Calculus I was listed as a pre-requisite to ensure the math skills necessary for the analysis of the systems. The goals of the class were to introduce students to several fundamental aspects of engineering systems and to provide problem-solving capabilities encountered in the design and analysis of those systems. Topics included math (roots of equations, complex numbers, matrices, vectors, dot product, and cross product), mechanical systems (2D and 3D statics principles), electrical systems (analysis of DC and AC circuits using Kirchhoff's Voltage Law and Kirchhoff's Current Law), mechanical energy systems (potential energy, kinetic energy, and work), and digital systems (number systems, digital circuits, and logic diagrams).

After two years it was obvious that the course in this structure was unacceptable since 28% of the students were earning D's and F's. The intent of this course was not to "weed" out students, and it was clearly not accomplishing its purpose of motivating students to continue in the engineering major. In spring of 1997, two members of the faculty were charged with restructuring the course so the students might have greater success. The "minimum self-paced mastery" technique was adapted to this course and the results were an improvement in retention to the next course. (See Williams and Newberry (1998)[4] for more information on this technique.) Approximately 16% of the students received D's and F's each year in the subsequent two years after the new course was introduced. According to Williams and Newberry, the retention rate of students at the end of the follow-on course, EGR 2320 Statics, also improved. They reported that 63% of the students completing Statics received a "C" or better in the course compared with 49% prior to the "mastery" course technique.

Although the content of the course remained essentially the same, a two-hour problem solving lab session was offered in which the students could ask questions in preparation for their "mastery" test. In fall 2000, the catalog was changed to reflect this lab session and the course description rewritten. The course material at this time was changed to include engineering mathematical concepts and problem solving using a handheld calculator or computational software. This change was enacted at the request of faculty of higher-level courses who perceived a weakness in their students in these areas. The topics included matrix algebra, linear equations, complex numbers, elementary operations with vectors, scalar product, vector product, set theory, Boolean algebra, and probability. The new description was as follows:

> EGR 1302 Introduction to Engineering Fundamentals – Introduction to fundamental problem solving techniques in engineering analyses of mechanical and electrical systems. (2-3)

The goal of this new restructured course was to advance the students' knowledge and skill in their ability to do the following:

1. Apply knowledge of mathematics, science, and engineering.
2. Identify, formulate, and solve engineering problems.
3. Use the techniques, skills, and modern engineering tools necessary for engineering practice.

While the goals of these courses were to help students understand the engineering profession and make an educated decision about this profession as a life vocation, the result was that about 50% of the students who take EGR 1301 leave the major or do not declare engineering as a major after their freshman year (see Table 1). In the 1994-1995 and 1995-1996 academic years, approximately 22% of students who took EGR 1301 graduated with an engineering degree. In the 1996-1997 and 1997-1998 academic years, the number of entering students who successfully completed degrees rose to approximately 32.3%. While an improvement, this graduation rate is below the national average. Thus, the School of Engineering and Computer Science to began a study on retention to determine what factors influence a student to remain in engineering and what can be done to increase retention of these students.

Retention Focus – Texas Technology Workforce Development Grant Program

The State of Texas has undertaken a rather ambitious program to increase the number of engineering and computer science graduates from the State's public and private institutions of higher learning. The State legislature allocated $5 million in state funds and sought a matching $5 million from Texas' private/corporate sector to fund the Texas Engineering and Technology Consortium's (TETC) grant program. Texas universities with ABET accredited Electrical or Computer Engineering programs were eligible to apply. Baylor University has sought funding with two proposals, one a joint proposal in collaboration with fourteen other Texas schools and a separate proposal focused on engineering program growth at Baylor.

However, the high-tech economic downturn began just as corporate sector fundraising was gaining momentum and full funding did not materialize. TETC was only able to raise $2.55 million from corporate donors in 2002. Of the proposals that were approved for funding, only 52% of the requested funding was made available. The TETC funded proposals were primarily targeted toward recruitment and student retention with projections for a 13% increase in enrolled students in the fall of 2003.

Texas Engineering Education Pipeline

Fifteen Texas universities lead by Southern Methodist University (SMU) requested $1.075 million to implement the Infinity Project statewide. The Infinity Project is a curriculum reform/development effort designed to place engineering curricula in grades 8 through 12 and first year engineering programs. This program included teacher training and well designed curricular modules that should attract students into the engineering and computer science (ECS) professions. The central program goal is to increase the number of entering freshmen ECS students in Texas institutions from 2900 to 5000 over the two-year grant period.

Each of the fifteen institutions would become a training and support center for high school teachers in their geographic area. In addition to teacher training, funds were requested to support collaboration between university faculty and students and high school faculty and students not only to provide a technical support network, but also to connect each high school student with a mentor from the engineering profession.

The Infinity Project also provides the basic curriculum elements for a freshman level introductory course in electrical and computer engineering in both community college and university level engineering programs. The stated goals for this phase of the project include increasing the retention rates for freshman engineering and computer science students to 75%.

The funding for the freshman level part of the Infinity Project was provided through a TETC grant. Funding for the high school initiatives was to be provided by a special grant from state education funds. However, the state education funding did not develop and the present budget shortfall in Texas, estimated at $6 billion, makes future funding unlikely. Because Baylor is a private institution, eligibility for a TETC grant was conditional on Baylor providing dollar for dollar matching. Ultimately, Baylor was awarded a TETC grant under the Infinity Project umbrella and is presently using these funds in freshman-level course development and retention efforts.

Strategies to Increase Enrollments

Baylor's second grant request would have supported the implementation of four strategies to enhance engineering retention: 1) employing a Retention/Success Coordinator, 2) attracting students from small liberal arts based Texas colleges via transfer agreements and targeted scholarship aid, 3) attracting a greater diversity of well-qualified students from high school using directed recruiting and scholarship incentives, and 4) providing funds for faculty and curriculum development, including areas of mathematics and science that are part of the broader engineering curriculum. This TETC grant proposal was not funded

The Retention/Success Coordinator is thought to be an important element in student retention and success. There are indications that the transition from high school to college academics is traumatic for a large percentage of entering freshmen, including those with high achievement records. (For example, Baylor University has a class attendance policy and not meeting the minimum number of classes required by a course results in failure. Attendance records kept by the EGR 1301 professors show approximate 6% of the students fail the introductory engineering course for not attending class.) A significant cause of this trauma is the lack of academic challenge and rigor in most high school programs. Approximately one-third of engineering students at Baylor graduate in the second quartile of their high school class. These students discover that they have moved from being "above average" students to being "below average". Many of these students come with learning skill sets that are not commensurate or competitive with first quartile peers, and they discover that the college academic environment is much more

difficult than they had anticipated. The Retention/Success Coordinator was to be tasked with identifying at-risk students early, hopefully within the first two weeks of a semester, and with marshalling tutorial resources to counter at-risk behavior.

Many aspects of student retention are influenced by the nature of the curriculum itself and by the pedagogic attitudes and skills of the faculty. Retention efforts in engineering can very well be undermined by non-engineering faculty in mathematics, physics, and chemistry as well as the faculty that support the general education portions of the curriculum. To support engineering retention efforts, Baylor is seeking funds to extend the development of "best of pedagogy" concepts to the non-engineering faculty through learning workshops and seminars and to increase cooperative relations between the engineering and non-engineering faculty.

Retention Focus – The Effects of Participation in Technical Societies on Retention

As a result of the success of the newly formed Baylor student section of the Society of Women Engineers (SWE), a study of participation in that organization was conducted to see if it significantly affected retention in computer science and engineering. The Baylor student section of SWE was officially chartered in 2000-2001, after their highly successful probationary year. Because of their innovations in recruiting and retaining members, they won the "Best New Student Section" in their Region, and the "Best New Student Section" in the nation, awarded at the annual conference in June, 2001. During the study, data were collected and analyzed to determine whether participation in SWE had a significant effect on retention. Based on the analysis performed and presented at the 32nd Frontiers in Education Conference in November, 2002, there is support for the hypothesis that the proportion of SWE student members graduating is greater than the proportion of non-SWE student members graduating. The data collected were also analyzed to determine if participation in SWE significantly affected retention, and the analysis showed that there is support for the hypothesis that the proportion of SWE student members leaving the Engineering or Computer Science programs is less than the proportion of non-SWE student members leaving the program. The complete analysis can be found in Fry and Allgood (2002)[5]. A continuation of that study is in progress, including the collection and analysis of data from the other technical societies at Baylor, with the possibility of expanding this study to other universities.

Conclusions

Student retention and success must capture the attention of individual engineering faculty as well as engineering administrators because the causes of student attrition are complex in terms of root causes and the generation of remedies. Attrition can be traced to a wide range of causes including the lack of academic rigor in high school curricula, the inadequacy of university freshman curricula, university faculty that promote the sink or swim version of academic self-reliance, and the lack of support staff. In this light, Baylor is wrestling with the broader implications of student retention and seeking solutions that, in combination, will create a learning environment that generates success.

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