# AC 2011-391: TIME TO COMPLETION OF AN ENGINEERING BACCALAUREATE AT TEXAS A&M UNIVERSITY

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# Time to Completion of an Engineering Baccalaureate at Texas A&M University for Underrepresented Students

## Introduction

In addition to the rising cost of college attendance, higher education administrators and governing groups are scrutinizing time to graduation for baccalaureate degrees.[1] At a time when many are calling for three year programs,[2] the US Department of Education increased the reporting metrics for graduation from six to eight years, in part due to the increasing length of time students are taking to complete a baccalaureate degree.[3, 4] In engineering, the drive to increase the number of engineers has focused on recruitment and retention (primarily in the first-year). Recent studies indicate that the pool of engineering students are those entering as first time students, since very few migrate into engineering.[5] There are many studies on the number of students completing degrees in STEM disaggregated by major or discipline area[6,7] with regard to gender and race.[8, 9] However there is less knowledge about students' progress beyond the first year through the undergraduate pipeline.[6]

The piece of the baccalaureate engineering pipeline that has been studied most often is progression through the foundational, or "barrier," courses that include calculus, chemistry, and physics.[10-14] In 2006, Kimball[15] conducted a study on time to completion of the initial set of engineering courses in the Dwight Look College of Engineering at Texas A&M University for the 1998 and 1999 first year cohorts. The purpose of this study was to determine the relationship of gender, ethnicity, engineering major, unmet financial need, cumulative grade point average, and total transfer hours on time to completion of initial engineering courses for first year engineering students at Texas A&M University. Statistical significance was found for the following variables: cumulative grade point average, gender, ethnicity, and unmet financial need. The 1998 and 1999 cohorts were selected because these were the first two classes after the College implemented the requirement for completion of a defined set of courses before advancing to sophomore level or higher status.

A follow up study of these two cohorts was conducted in 2010, with graduation data collected through May 2009. Of the 1,185 students from the initial study, all but 67 had graduated from Texas A&M University by May 2009 (94.3% retention to the institution). Furthermore, 1,063 of these students graduated from the College of Engineering. Unsurprisingly, for engineering graduates the number of semester to completions of the initial courses was positively correlated to the number of semesters to graduation (Pearson $r = .363$ $p < 0.0001$). This paper details the findings relevant to underrepresented minority (URM) students from the follow up study.

Historically, minority students are underrepresented in higher education, particularly at four-year institutions; only 30% of all undergraduates in 1999-2000 were minorities.[16] The significant demographic shift from a predominantly White population toward a growing minority population in the past ten to fifteen years has led to targeting this pool of students for enrollment and retention in higher education, and in particular in engineering and the science.[17-22] In

engineering, Hispanic and African American enrollment has increased while White enrollment has decreased slightly, but Hispanics and African Americans are still significantly underrepresentation among engineering majors.[9] Furthermore, underrepresented minority students in science and engineering are also more likely than others to drop out of these majors.[23] However, there are some considerations. For example, nationally, URM students are most likely to be first generation students (i.e. their parents had no more than a high school education).[24]

Questions examined in this paper are:

- Are URM students retained to graduation in engineering at the same rate as non-URM students?
- Is there a difference in time to graduation in engineering for URM and non-URM students?
- What is the relationship of cumulative grade point average, gender, unmet financial need to time to graduation for URM and non-URM students?

Findings from the 2006 Study

The 2006 study examined time to completion of initial engineering coursework, usually defined as the first year courses in calculus, chemistry, physics, and introduction to engineering. These are often considered the stumbling points or "barrier courses" to an engineering baccalaureate degree. Texas A&M University calls these initial courses the Core Body of Knowledge (CBK). Beginning in 1998, CBK has been defined as the engineering lower-level required courses of General Chemistry for Engineering Students, Composition and Rhetoric, Foundations of Engineering I & II, Engineering Mathematics I & II (Calculus), and Physics I (Mechanics) or equivalents.[25]

Statistical analysis conducted in the 2006 study of the 1998 and 1999 cohorts of first-year engineering student found female engineering students completed these required courses, or CBK, faster than males ($p = 0.008$). African American and Hispanic women completed CBK faster than males of the same ethnicity. Though statistical significance was not found for these underrepresented minority (URM) women, the findings are relevant in that data were of the entire student population, or all students enrolling as first time in engineering majors in 1998 and 1999.[26] URM students took slightly longer to finish CBK ($p = 0.001$) than non-URM students. Students with no financial need finished CBK faster than those with financial need ($p = 0.001$), with perhaps a greater impact on URM students due to research indicating that this group have a greater dependence on financial aid to pay for college.[27-29] No significance was found for SAT/ACT scores or number of credit hours from AP/dual credit.

Method

Data were collected for all 1,185 first-time in college students from the 1998 and 1999 cohorts whose ***initial*** major was chemical, civil, computer, electrical, or mechanical engineering and who had completed CBK by 2004. The original data set (2006 study) included initial major, ethnicity, gender, SAT/ACT scores, number of credit hours from AP/dual credit, and financial need as well as number of semesters to completion of CBK and grade point average (GPA) at

time of completion of CBK. Additional data collected in 2010 included number of semesters to graduation, GPA at graduation, and major at graduation. Transfer students were not considered.

It is important to note that although most graduation studies are 6 years, this present study is 10 years for the 1998 cohort and 9 years for the 1999 cohort. This was done to attempt to track all students to completion. All of the 1,185 students from the initial study had either left the university or had graduated with a bachelor's degree; none were still enrolled as undergraduate students at Texas A&M University by 2009. Students were not tracked beyond their baccalaureate degrees. All analyses from the initial study were repeated for the graduation data to determine if trends seen in time to completion of CBK were the same at graduation.

Results

*General Graduation Results.* The follow up study found that of the 1,185 students in the 2006 study (1998 and 1999 cohorts) who completed CBK and progressed to upper division, 1,063 (89.7%) earned a bachelor's degree in engineering by the end of the Spring semester 2009. Students in the initial study averaged nearly three semesters to completion of CBK rather than the two semesters listed in the university catalog. In the follow-up study, the students who graduated in engineering averaged a total of five years (9.7 semesters) to complete their degrees (Table 1).

Table 1: Semesters to Complete CBK correlated to Graduation

| | **Mean** | **SD** |
|---|---|---|
| Semesters to Completion of CBK | 2.81 | 1.000 |
| Semesters to Graduation | 9.70 | 1.395 |

Proportionally, the engineering graduates of the 1998 and 1999 cohorts "looked like" the gender and ethnicity of the incoming classes. In the 2006 study, 82.4% of the students completing CBK were male and 17.6% were female. Of the engineering graduates, 878 (82.6%) were male and 185 (17.4%) were female. Ethnicity of the students who earned an engineering degree is proportionally also proportionally similar to the students who completed CBK. Table 2 shows the ethnicity of the 1,063 graduates who completed earned engineering degrees at Texas A&M and were in the 1998 and 1999 engineering student cohorts.

Table 2: TAMU Engineering Graduates - 1998 & 1999 cohorts

| | Graduates by 2009 | Original Population who completed CBK | Percent Retained to Engineering Degree |
|---|---|---|---|
| African American | 27 (2.5%) | 30 (2.5%) | 90% |
| Hispanic | 76 (7.1%) | 88 (7.4%) | 86.3% |
| American Indian | 2 (0.2%) | 2 (0.2%) | 100% |
| Other/Asian | 66 (6.2%) | 78 (6.7%) | 84.6% |
| White | 892 (83.9%) | 987 (83.2%) | 90.4% |
| Total | 1,063 | 1,185 | 89.7% |

Table 3 further indicates the gender and ethnicity of the 1,063 engineering graduates.

Table 3: Gender and Ethnicity of TAMU Engineering Graduates from 1998 and 1999 Cohorts

| Ethnicity | Male | Female | Total |
|---|---|---|---|
| African American | 13 | 14 | 27 |
| Hispanic | 61 | 15 | 76 |
| American Indian | 2 | 0 | 2 |
| Other/Asian | 49 | 17 | 66 |
| White | 753 | 139 | 892 |
| Total | 878 | 185 | 1,063 |

*Time to Graduation and Ethnicity.* Although only 16.4% of the engineering graduates had completed their degrees within 4 years (8 semesters), by six years (12 semesters) 96% had graduated. Table 4 indicates time to graduation for all students in the original 2006 study. Table 5 further details the number of semester by ethnicity for engineering students graduating by May 2009. Statistical significance was found in that White students graduated faster than African American students ($p = 0.001515$) or Hispanic students ($p = 0.0020025$). No other differences were statistically significant. However of the nine students who took more than 7 years (14 semesters) to graduate, six were White males (Figure 1). Figure 1 also shows that by 4½ years (9 semesters), half of the non-URM engineering graduates completed their bachelor's degrees. It was 5 years (10 semesters) before more than half the African American or Hispanic students graduated.

Table 4: Semesters to Graduation

| | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| All graduates | 9.76 | 1.48 | 6 | 20 |
| All Engineering | 9.70 | 1.40 | 6 | 20 |
| Not URM Engineering | 9.64 | 1.39 | 6 | 20 |
| URM Engineering | 10.21 | 1.38 | 6 | 15 |
| Non-Engineering grads | 10.93 | 2.30 | 8 | 19 |
| Semesters at Texas A&M University Non Grads | 8.06 | 3.90 | 2 | 20 |

Table 5 Semester to Graduation by Ethnicity

| | Mean | SD |
|---|---|---|
| African American | 10.41** | 1.047 |
| Hispanic | 10.14** | 1.485 |
| American Indian | * | |
| Other/Asian | 9.91 | 1.707 |
| White | 9.62 | 1.358 |

*too few students to report

** $p < .01$

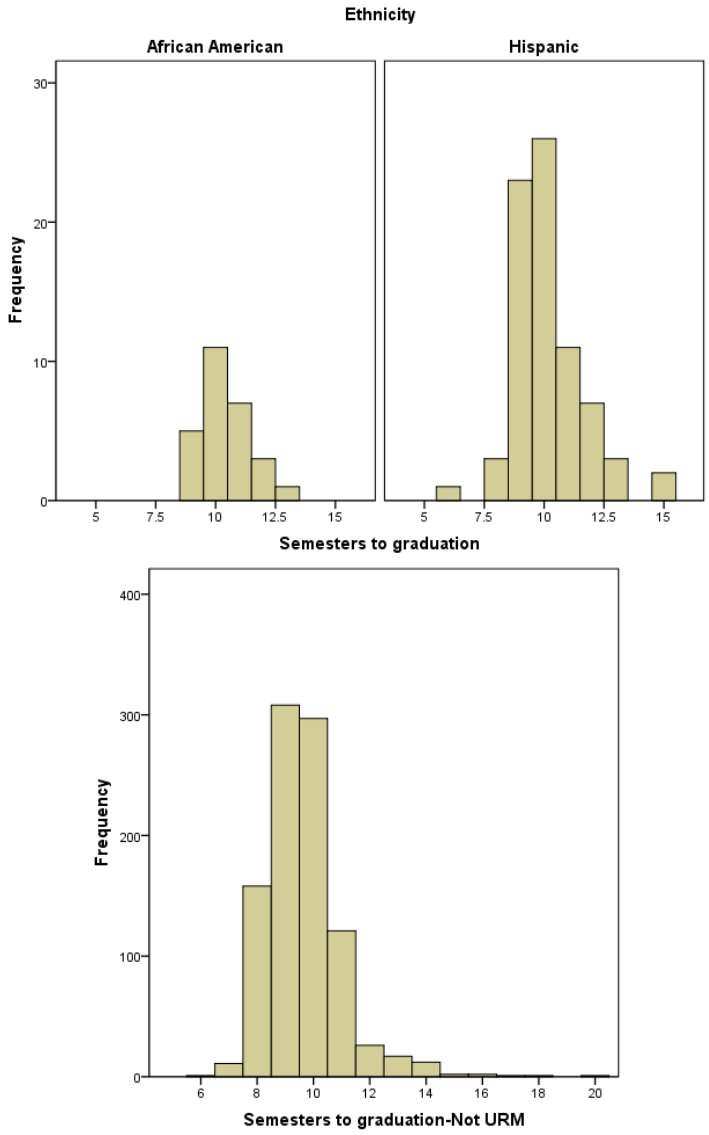


Figure 1. Semesters to graduation by ethnicity

*Correlations between Time to Graduation and Other Variables.* In the initial 2006 study, statistical significance was found in the relationships between the time to completion of CBK and the variables of cumulative grade point average, gender, ethnicity, and unmet financial need.

Time to completion of CBK. The number of semesters to completion of CBK was positively correlated to the number of semesters an engineering student took to graduation (Pearson r = .363 $p < 0.0001$). Table 6 shows the correlation between time to completion of CBK and time to graduation for all groups. The correlation between time to completion of CBK and time graduation was the strongest for those graduates leaving engineering.

Table 6: Correlations Semesters to CBK and Graduation

| | r** |
|---|---|
| All graduates | 0.378 |
| All Engineering | 0.363 |
| Not URM Engineering | 0.349 |
| URM Engineering | 0.396 |
| Non-Engineering graduates | 0.625 |

** $p < .01$

Financial need. Underrepresented minority students from this study were more likely to be Pell eligible (41.9% to 10.3%) and have unmet financial need (37.1% to 13.8%). Both of these differences were statistically significant $p < .01$. However, there was no statistically significant difference in financial need between engineering graduates, non-engineering graduates, or non-completers. Table 7 shows the percentages of financial need for URM and non-URM engineering graduates, all engineering graduates, non-engineering graduates, and non-completers. The numbers of URM non-engineering graduates and non-completers is too small to be significant. Furthermore, engineering graduates who were Pell eligible or had unmet financial need took longer to graduate ($p = .00001$) than students without financial need. This matched the results of the 2006 study for time to completion of CBK.

Table 7: Financial Need of All Students in 2006 Study by Graduation Status

| | No need | Pell and/or Unmet Need |
|---|---|---|
| All Engineering | 79.2% | 20.8% |
| Not URM Engineering | 83.0% | 17.0% |
| URM Engineering | 44.8% | 55.2% |
| Non-Engineering grads | 76.4% | 23.6% |
| Non-completers | 76.1% | 23.9% |

Gender. In the 2006 study, women of all subgroups completed CBK faster than their male counterparts. Likewise, among the engineering graduates, females graduated in fewer semesters than their male counterparts. However, though statistically significant for women in the overall population of this study, the difference was not statistically significant for URM engineering graduates (Table 8).

Table 8. Semesters to Graduation for Engineering Graduates by Gender

| | Male | | Female | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| All Engineering Graduates** | 9.75 | 1.417 | 9.48 | 1.264 |
| URM | 10.27 | 1.388 | 10.07 | 1.397 |
| Not URM** | 9.70 | 1.411 | 9.37 | 1.213 |

**$p < .001$

Cumulative Grade Point Average. Finally, the student characteristic with the strongest relationship to time to graduation is cumulative grade point average. Cumulative grade point average for all groups is shown in Table 9. For each group of graduates, the higher the cumulative grade point average, the shorter the time to graduation. The correlation was the strongest for URM engineering graduates.

Table 9. Cumulative GPA (CGPA) and Correlation to Semesters to Graduation

| | Mean CGPA | SD | r |
|---|---|---|---|
| All Graduates | 3.09 | 0.46 | -.503 |
| All Engineering | 3.10 | 0.45 | -.490 |
| Not URM Engineering | 3.13 | 0.44 | -.464 |
| URM Engineering | 2.83 | 0.48 | -.623 |
| Non-Engineering grads | 2.82 | 0.54 | -.530 |
| Non-completers | 2.29 | 0.57 | |

The difference between the cumulative grade point averages for URM students and non-URM students was statistically significant ($p < .00001$).

Discussion

Time to completion of an undergraduate engineering degree is an important topic, especially in light of today's concerns about the cost of higher education.[30] The US Department of Education increased reporting requirements for graduation rates (IPEDs data) from six years to eight years,[31] which may project a new standard from the traditional six year cohort studies. The good news from this study is that when these students completed their introductory coursework (CBK), 89.7% of them earned an engineering degree from Texas A&M University within 10 years. Underrepresented minority (URM) students graduated at the same rate as students who are not from underrepresented groups. URM women graduated faster than URM men, even though the difference was not statistically significant.

However on the average, URM students took longer to complete their degrees than students who were not URM. Only four (3.8%) of the URM students completed their engineering degrees within the catalog four-year (eight semesters), while 158 (17.7%) of the non-URM students had completed their degrees within four years. Factors that likely contribute to the longer time to completion for URM students are financial need and grades. URM students had statistically significant greater financial need and lower cumulative grade point averages than did non-URM students. Financial need concerns can often require students to work during the academic year and to thus take a lighter course load which results in a longer time to graduation.[30] A lower cumulative grade point average can be an indication of course re-takes which also lengthens time to graduation.

It is important to note that these cohorts matriculated after the 1996 Fifth Circuit Hopwood decision which stated that race could not be used in admission decisions. In 1997, the Texas Attorney General ruled that ". . . Hopwood's restrictions would generally apply to all internal institutional policies, including admissions, **financial aid**, **scholarships**, fellowships, recruitment

and **retention**, among others."[32] Thus, there were no special programs or support for URM students at this time. Three student organizations, the National Society of Black Engineers (NSBE), the Society of Hispanic Professional Engineers (SHPE), and MAES were the only support groups for URM engineers. All first year women engineering majors were invited to live in the designated dorm in an engineering living learning community (ELLC), and honors students could choose to live in the honors dorm. URM males were not included in the ELLC until 2002. However, there were no other specific recruitment, financial, or retention support efforts for any group of students in 1998 and 1999.

For the 1998 and 1999 cohorts, the retention efforts used by the Dwight Look college of Engineering at Texas A&M appear to have been successful. Ongoing studies are needed to determine if this continues to be true. Time to completion for all students, but most especially for URM students continues to be a concern. Efforts are needed find mechanisms to reduce URM students' financial burdens and to increase their cumulative grade point averages.

Recommendations

The good news from this study is that URM students graduated in engineering at the same rate that they completed the introductory engineering courses, or CBK. If this is true across other cohorts at Texas A&M and at other universities, this is encouraging for the retention to graduation of URM engineering students past the "barrier" courses. While many of the students from the 2006 cohort changed departments within engineering, 89.7% of them earned a bachelor's degree in a major in the College of Engineering.

The bad news is that the number of URM engineering graduates is far too small. Evidence from this study implies that a continued focus on recruitment and retention through barrier courses holds the most promise for increasing the number of diverse engineers. Furthermore, with the increased cost of attendance at many institutions, financial need and time to graduation will become even more critical. Efforts to meet the financial needs will continue to be urgent as will the development of mechanisms to reduce time to completion of both foundation engineering courses and graduation. As mechanisms are developed, ongoing research to examine impact and effectiveness will be needed.

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