
AC 2011-63: WOMEN AND TIME TO COMPLETION OF AN ENGINEERING BACCALAUREATE AT TEXAS A&M UNIVERSITY

Jorja Kimball, Texas Engineering Experiment Station

Jorja Kimball, PhD serves as the Director of Strategic Research Development for the Texas Engineering Experiment Station, a state-wide research agency of the Texas A&M University System. In this capacity she works with institutions of higher education across the state of Texas to strategically develop education and technical research proposals that will bring federal research dollars into Texas. Her office has garnered over \$66 million in federal funding since 2003 for educational research, in addition to working with faculty who received individual technical awards, such as the NSF CAREER. Dr. Kimball has a BBA and MBA from Texas A&I University and a Ph.D. from Texas A&M University in Educational Administration (Dissertation: A Study of Engineering Student Attributes and Time to Completion of First Year Required Course at Texas A&M University). She was with the College of Engineering at Texas A&M University-Kingsville, A Hispanic Serving Institution, for eight years before her employment with TEES. There she was a Principal Investigator and held a number of leadership positions on projects related to engineering education, such as the \$30 million NSF Foundation Coalition for Engineering Education. She also has extensive experience with undergraduate and graduate education, particularly related to underrepresented minorities and women.

Margaret Hobson, Texas A&M University

Margaret Hobson, Ph.D. serves as an Assistant Director of Strategic Research Development for the Texas Engineering Experiment Station, a state-wide research agency of the Texas A&M University System. Dr. Hobson has a B.S. from Texas Woman's University and an M.S. and a Ph.D. from Texas A&M University in Educational Psychology (Dissertation: Teacher Perceptions of Change in Leadership Roles and Activities as a Result of Participation in a Science Education Leadership Program). Her dissertation study was supported by the National Science Foundation project Center for Applications of Information Technology in the Teaching and Learning of Science (ITS Center). Dr. Hobson also has extensive experience in evaluation. Prior to joining TEES, Dr. Hobson taught mathematics and special education in three Texas public school districts between 1976 and 2000.

Women and time to completion of an Engineering Baccalaureate at Texas A&M University: Women and sub-groups of Women Finishing Core Coursework Faster

Introduction

In addition to the rising cost of college attendance, higher education administrators and governing groups across the nation are beginning to scrutinize time to graduation rates of baccalaureate degrees.¹ The US Department of Education recently increased the reporting of university graduation rates from six to eight years, due to the increasing length of time students are taking to complete a baccalaureate degree. The increase in time to complete a degree is attributed to factors, such as increased cost of attendance and student employment to help pay for college, which may cause part-time enrollment.^{2,3} A study by an NSF funded engineering education center, indicates that the pool of engineering students remains those entering as first time students, since very few students migrate into engineering from other degree paths.⁴ There are many studies on the number of students completing degrees in STEM disaggregated by major or discipline area^{5,6}, and for ethnicity or race and gender.^{7,8} However there very few studies on students' timely progression through the STEM undergraduate pipeline.⁵

In 2006, a preliminary research study on time to completion of the initial set of engineering courses at the Dwight Look College of Engineering at Texas A&M University was conducted with data from the 1998 and 1999 first year cohorts. It found that women completed these courses, termed Core Body of Knowledge (CBK) at Texas A&M, in significantly ($p=.001$) less time than their male counterparts.⁹

A follow up study of these two cohorts was conducted in 2010, with graduation data collected through May 2009. Ten years of data were used from 1998 and 1999 cohorts to 2009 to ensure that students did not remain in the pathway to a degree. Of the original 1,185 students from the 2006 study, all but 67 had graduated from the university by May 2009 (94.3% retention to the institution). Furthermore, 1,063 of these students graduated from the College of Engineering.

Unsurprisingly of the students earning a degree in engineering, results indicate that the number of semesters to complete CBK was positively correlated to the number of semesters to graduation (Pearson $r = .363$ $p < 0.0001$). This, plus preliminary results of an in-process study that women engineering students at Texas A&M are achieving higher grade point averages (GPA) than men. The GPAs of women (3.17 GPA) to that of men (3.09 GPA) was statistically significant with a $p = .009$, with the findings currently under review for use in the College's diversity plan metrics. This diversity plan is required by the university and ties to the College's recruitment plan to increase engineering enrollment of underrepresented students, which includes all women.^{10,11} These findings are not unique, since research indicates that women in engineering are well prepared and perform well academically,^{9,12-16} but are now documented for further study by the College. This continuation study was undertaken, in part, to compare findings at Texas A&M to recent research on persistence and graduation, particularly for women and women of color.^{17,18}

Findings may also lend to the very limited publications associated with time to completion of an accredited standard¹⁹ first-year engineering curriculum.²⁰ This could also link to current issues associated with college costs resulting in rising student debt and be a means of cost containment in higher education without increasing tuition and fees. Due to the quantitative nature of this study, recommendations for further qualitative study are also suggested to seek answers to “why” this occurs. Since statistical significance was not found to differentiate women and men entering engineering at Texas A&M based on student SAT or ACT scores and GPA.

Findings from 2006 Study

The 2006 study reviewed time to completion of initial engineering coursework at Texas A&M, which is defined as the first two semesters of calculus, chemistry, and physics. These are often considered the stumbling points or “barrier courses” to an engineering baccalaureate degree, with engineering educators commonly aware that the greatest loss of students occurs during the first and second years of engineering majors. Texas A&M University, which enrolled over 9,000 engineering students during 1998 and 1999, terms this initial coursework the Core Body of Knowledge (CBK). CBK is defined as the engineering lower-level required courses of General Chemistry I for Engineering Students, Composition and Rhetoric (English), Foundations of Engineering I & II, Calculus I & II, and Physics I & II, or equivalents.²¹

Statistical analysis conducted in the 2006 study of the 1998 and 1999 cohorts of entering engineering students found that women engineering students completed these required courses, or CBK, faster than men at the .01 level ($p = 0.008$). Statistical significant for gender and ethnicity was found between White male and White female students at the .01 level ($p = 0.008$). Descriptive analysis indicated that of the five majors studied (chemical, civil, computer, electrical, mechanical engineering), African American and Hispanic women completed CBK faster than men of the same ethnicity. Though statistical significance was not found for these underrepresented women (African American, Hispanic), the findings are relevant in that data was of the entire population of all students enrolling as first time in engineering majors in 1998 and 1999 and completing CBK.⁹

This follow-up study built on these findings, and examined the time to graduation for students from the 1998 and 1999 cohorts that completed CBK. Analysis was completed for the research question of did women complete and engineering degree and graduate at a faster rate than men.

Method

Data were collected for all 1,185 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 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.

It is important to note that although most graduation studies are 6 years, this follow-up study is 10 years for the 1998 cohort and 9 years for the 1999 cohort. This was done in an attempt to track all students to degree completion. 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 for time to 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, 1063 (89.7%) earned a degree in engineering by the end of the Spring semester 2009. Of these students, 878 (82.6%) were male and 185 (17.4%) were female, which almost exactly matches the male/female ratio of the original first-time entering cohorts (1998 and 1999) of 82.4% male, 17.6% female. All of the 1,185 students from the initial 2006 study had either left the University or had graduated; none were still enrolled as undergraduate students at Texas A&M by 2009.

Table 1 shows the gender and ethnicity of the graduates. Proportionally, engineering graduates of the 1998 and 1999 cohorts “looked like”, or matched closely, the gender and ethnicity of the entering classes.

Table 1: Gender and Ethnicity of TAMU Engineering Graduates from 1998 and 1999 Cohorts

Ethnicity	Male		Female		Total		Percent retained in Engineering
	2006	2010	2006	2020	2006	2010	
African American	13	13	17	14	30	27	90%
Hispanic	70	61	18	15	88	76	86.3%
American Indian	2	2	0	0	2	2	100%
Other/Asian	60	49	18	17	78	66	84.6%
White	832	753	155	139	987	892	90.4%
Total	977	878	208	185	1185	1063	89.7%

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 2 shows the mean semesters to completion and graduation for engineering graduates, who finished CBK in the initial 1998 and 1999 cohorts.

Table 2: Semesters to Complete CBK correlated to Graduation

Semester	Mean	SD
Semesters to Completion of CBK	2.81	1.000
Semesters to Graduation	9.70	1.395

The median time to graduation for women was 4 ½ years and 5 years for men (Figure 1). Nonparametric median tests were used to compare semesters to graduation for women and men (Mann-Whitney $U = 73543$, $p = .018$). However, statistical significance was not found ($p = 0.09$) between the grade point average of men (3.09) and women (3.17). Nor was it found for SAT or ACT measures comparing male and females students. Thus, the academic achievement

or preparedness of women engineering graduates in the 1998 and 1999 cohorts did not appear to differ substantially from men of the same cohorts.

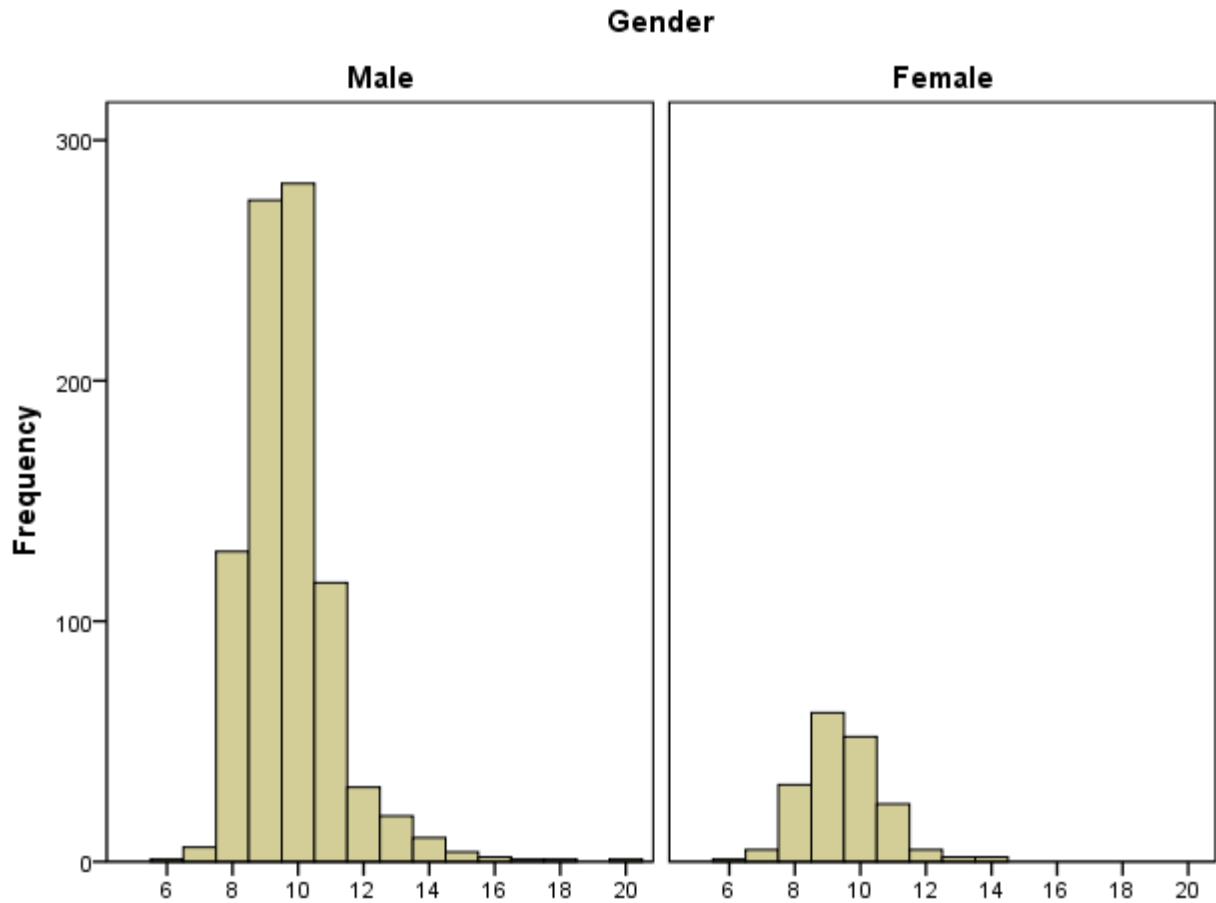


Fig. 1. Semesters to graduation

Of the 1063 student graduating with engineering degrees, thirteen students graduated in less than four years, with two students graduating in three years (a Hispanic female and 1 Other male) and the other 11 graduating in 3 ½ years (5 White females, 5 White males, 1 Other male). These thirteen had on average a cumulative GPA of 3.52. Women are well represented in this small yet high achieving group. In contrast, those taking more than 7 years to graduate as engineering majors had on average a GPA of 2.29.

Student data are not available on additional factors possibly contributing to time-to-completion, such as hours worked or part-time student status. However, data from 1998 and 1999 indicate that Texas A&M has a traditional student body in age and full-time enrollment status. For instance, of the 8,799 first-time entering students in 1999, 8,660 (98.4%) were full time and 8,767 (99.6%) were 21 years of age or younger.²²

Table 3 lists GPA, semesters to graduation, and semesters to completion of CBK for engineering graduates, non-engineering graduates (other), and those not graduating. Non-engineering, or

other, graduates had on average a lower GPA than the average GPA of those persisting in engineering, despite engineering requiring more hours than a majority of other majors.

Table 3: Comparison of 1998 and 1999 Engineering Majors completing CBK

	GPA*		Semesters to Graduation**		Semesters to CBK	
	Mean	SD	Mean	SD	Mean	SD
Engineering Graduates	3.10	0.45	9.7	1.4	2.8	1.0
Other Graduates	2.83	0.54	10.9	2.3	2.9	1.1
Not Graduating	2.29	0.57			2.8	1.1

*Adjusted R² = .158 **p = .000126

Of the 122 students departing engineering after CBK, 67 students did not graduate, with 16.4% of these being women. Data on students who graduated in other majors after completing the engineering CBK are shown in Table 4. Of the 12 women non-engineering graduates, two were underrepresented ethnic minority students (URM) and 10 were non-URM. GPAs for these URM women were 3.022 (African American) and 2.13 (Hispanic). Statistical significance was found for non-engineering women graduating faster than non-engineering men at p < 0.05 level.

Table 4: Data Summary for Non-Engineering Graduates

Non Engr. Grads	URM	Non-URM	Avg. GPA	GPA Range	Semesters to COMPLETE DEGREE*
Women	2	10	2.96	2.13-3.63	9.75
Men	41	2	2.8	1.61-4.0	11.26
Total	43	12			

*p < 0.05

Discussion

The gender and ethnicity of students in this study earning baccalaureate engineering degrees was very similar to those who completed CBK in the initial 2006 study, with women again graduating faster than men. Women completed their degree in approximately 4.5 years versus 5.0 years for men, or one less semester than men. With the rising costs of tuition nationally, the reduction of even one semester at Texas A&M, based on the current \$20,614 a year cost of attendance estimate, would result in a **savings of \$10,300.**²⁰ This would be of particular importance to students dependent on financial aid, since it is predominantly in the form of loans that must be repaid after graduation.

Results of this study showing women graduate faster than men, matches similar research by the Center for the Advancement of Engineering Education (CAEE) that found no difference in the persistence of women of all races to men. The 89% of students who complete CBK to graduate with an engineering degree in this study is comparable to the CAEE study results indicating that 93% of students matriculated in engineering by the eighth semester.¹⁷

Although only 16.4% of the engineering graduates beginning in 1998 or 1999 had completed their degrees within 4 years (8 semesters), by six years (12 semesters) almost 90% of these

students had graduated. Results indicate that once students complete CBK, the vast majority go on to graduate.

Findings from this study align with research indicating that the greatest loss of engineering students occurs during the first year, or during the time-period that engineering majors encounter so-called barrier courses (CBK at Texas A&M). Further, Ohland¹⁷ substantiates that engineering differs from other majors in the dearth of female students and low rate of migration into the major. Thus, retention of students entering engineering programs is vital to increase the number of engineering graduates. Recruitment will be vital to increase enrollment and graduation of those underrepresented in the field, namely women and minority students.

In order to address both time to degree completion and the need to recruit from a college age population that continues to grow more diverse, this study is an effort to understand factors contributing to the specific recruitment and retention of women in engineering. This type of study may also be meaningful to engineering colleges in the struggle with diminishing funds to create effective programs that increase enrollment of women and women of color (African American, Hispanic, and Native American).

Recommendations

The move by the US Department of Education in 2008 to changed reporting requirements in an effort to better capture graduation rates may move graduation cohort studies from the traditional six years to eight years or longer.²³ Therefore, colleges of engineering and their universities may be asked to address the length of time to degree completion, and not merely to increase the number of graduates. Analysis of this study indicates a very high graduation rate for engineering majors once CBK is completed. Therefore, further study is recommended related to examine mechanisms for decreasing the time needed to complete initial coursework, or CBK.

The authors recommend analysis of additional cohorts related to CBK and ultimately graduation, since the entrance requirements for the university and College of Engineering have increased substantially from more than a decade ago (1998 and 1999). If the new data still indicate that women complete CBK faster than men, additional quantitative analysis of women's preparedness (aside from SAT, ACT and rank in class that is currently used as entrance requirements) is merited. Additionally, recent research in student attitudes and commitment to engineering degrees might be replicated, with special attention paid to women and women of color.²⁴ Further study is recommended related to time-to-completion factors not addressed by this study.

Over the last decade, the cost of attendance for higher education has risen substantially. This may be contributing to the increased time to graduation rates, since the time needed for a student to work to pay college costs would impact how many courses they might successfully complete or pass.²⁵ Further review of this factor is warranted by colleges of engineering.

Colleges may wish to consider or study the possibility of recruitment and retention programs specifically for women/women of color, using findings from this study and others as guidelines for development. Being able to pinpoint efforts will also lend itself to cost effective engineering retention programs that may have limited budgets. Also, colleges may wish to undertake

qualitative studies of women who departed but remained in the university and subsequently graduated. A qualitative study of these women may answer the question of “why” women depart engineering.

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