

# **AC 2007-2963: A STUDY OF MINORITY ENGINEERING STUDENTS AND TIME TO COMPLETION OF FIRST YEAR REQUIRED COURSES AT TEXAS A&M UNIVERSITY**

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# **A STUDY OF MINORITY ENGINEERING STUDENTS AND TIME TO COMPLETION OF FIRST YEAR REQUIRED COURSES AT TEXAS A&M UNIVERSITY**

## **Abstract**

For many years, colleges of engineering across the nation have required the completion of foundational courses before a student could begin coursework in a specific engineering major. Since 1998, The Dwight Look College of Engineering at Texas A&M University (TAMU) has required that first-time enrolling students complete certain courses (termed the Core Body of Knowledge or CBK), with specific cumulative grade points required for specific majors. With the pressure to increase the number and diversity of US engineers, retention, especially first-year retention, and time to degree became important issues. However, the relationship between time to completion of foundational coursework and student characteristics and academic factors had not been previously examined by TAMU. Therefore, a study of first-year engineering students at TAMU was conducted to determine the relationship of ethnicity, gender, engineering major, unmet financial need, and cumulative grade point average on time to completion of CBK courses.

Results of interest were those involving the variables gender, ethnicity, and unmet financial need. Statistical significance was found for the following variables in this study: cumulative grade point average (CGPA), gender, ethnicity, and unmet financial need. Analysis indicates that CGPA has the strongest relationship to completion of CBK of any independent variables in the study. For the study's variable of major, statistical significance with time to completion of CBK was found for Chemical, Electrical, and Computer Engineering majors. Findings with implications for recruitment and retention of underrepresented minority students in engineering are presented.

Further study to determine profiles of those majors where statistical significance was found for students taking a greater or lesser amount of time for CBK completion than the mean is recommended, as is ongoing data collection and comparison for current cohorts of engineering majors by ethnicity and gender at TAMU.

## **Rationale**

During the past decade, there has been a national focus on increasing number the number and diversity of B.S. engineers. This along with the substantial increases in the Hispanic population, have caused many colleges of engineering to review the issues involving recruitment and retention of U.S. undergraduate students. Minorities comprise a significant portion of the U.S. population and have accounted for almost all of the relative growth in college enrollment from 1980-2000 [1]. Along with women, minority students (African American, Hispanic, and Native American), continue to be significantly underrepresented (16%) among engineering undergraduates [2, 3], and are also more likely than others to change out of science and engineering majors [4].

Though studies exist on the retention and matriculation of minority students in engineering [5-9], little information in the research literature relates to "time to

completion” of required courses that in colleges of engineering are the pre-requisites to taking upper level engineering coursework [10].

Texas A&M University (TAMU) is a major research institution enrolling over 9,000 engineering students. TAMU also ranks among the top 20 U.S. institutions awarding bachelors’ degrees to Hispanics [11], and therefore, was chosen for this study to analyze time to completion of required pre-requisite courses for first time entering engineering majors. TAMU refers to these required courses as the Core Body of Knowledge (CBK). Each department within the Dwight Look College of Engineering at TAMU currently requires specific overall grade point average (GPA) upon completion of the required CBK courses. A grade of “C” or better must be earned in each CBK course in addition to the required departmental GPA to advance to upper level status and take courses in the student’s designated major. However, the number of semesters necessary to achieve the required CBK and overall GPA is currently not considered.

CBK is defined as the required lower level courses of General Chemistry for Engineering Students (CHEM 107), Composition and Rhetoric (ENGL 104), Foundations of Engineering I & II (ENGR 111 and 112), Engineering Mathematics I & II (MATH 151 and 152), and Mechanics (PHYS 218) or equivalent at Texas A&M University [12]. This study examines the 1998 and 1999 cohorts of first-year enrolling engineering students in the Dwight Look College of Engineering (Engineering) at Texas A&M University (TAMU) to review the time to completion of the CBK, or the series of coursework that includes the first two semesters of chemistry, calculus, and physics that nationally constitute the stumbling points or “barrier courses” for first-year engineering students.

Much of the TAMU engineering student’s first year of coursework provides the required CBK courses, which allow entrance to upper level engineering courses. At present, departments in Engineering at TAMU focus only on attainment of a certain GPA in these CBK courses for students to be allowed to enroll in upper level courses in a specific major. This study provides 1) insight into the question of whether time to completion of CBK is a valid consideration for departments to make when allowing students to enroll in upper division engineering courses, and 2) information on whether differences exist in completion time of CBK based on gender, ethnicity, cumulative grade point average, engineering major, or financial need. Results for this paper focus on results related to ethnicity of the students.

Astin [13] highlighted a number of issues affecting student persistence, including parental income, as his research indicated lower family income lessens a minority student’s chance at obtaining a four-year degree. This study will use the variable unmet financial need, which is defined as a student qualifying to receive financial aid as a proxy for parental income, based on calculations by the TAMU Office of Student Financial Aid. Students not applying or qualifying for financial aid will be determined not to have financial need.

## **RESEARCH DESIGN**

### **Population**

The cohorts of first time enrolling engineering students from 1998 and 1999 were chosen since 1998 was the first year that CBK was required of all majors in the College of Engineering at TAMU. The addition of students from 1999 allowed for a large enough population in the study after the anticipated need for elimination of faulty or missing data. Table 1 indicates the number of student records obtained and the number used for this study.

The initial 1998 and 1999 data set obtained from the Engineering Academic Programs Office contained 2,657 students, with data coded to avoid possible identification of individual students. The list of students was then narrowed to the five majors targeted by this study: Chemical, Civil, Computer, Electrical, and Mechanical engineering. These five majors were selected since they are offered by a majority of colleges of engineering in the U.S. There are approximately 345 colleges of engineering in the United States of which the following offer degrees in the five targeted majors: 154 in Chemical Engineering, 217 in Civil Engineering, 153 in Computer Engineering, 254 in Electrical Engineering, and 268 in Mechanical Engineering [14]. Further, of the 30 universities that TAMU College of Engineering considers peer institutions, 26 colleges offer all five majors with the remaining colleges of engineering offering four of the five majors targeted by this study [15, 16].

The refined data set containing information on 1,165 first-time enrolling engineering students at TAMU was used for the descriptive parameters and statistical analysis of this study, not including transfer students. Because this is a population study and a sample was not drawn, all analyses are of parameters, not statistics.

**Table 1: Population of the Study by Cohort Year**

<b>Cohort</b>	<b># Entering (initial data)</b>	<b># Not major of Interest</b>	<b># not progressing</b>	<b># w/ missing data</b>	<b>Number Used</b>
1998	1494	299	479	42	674
1999	1163	227	426	19	491
<b>Total</b>	<b>2657</b>	<b>526</b>	<b>905</b>	<b>61</b>	<b>1165</b>

### **Descriptive Parameters**

Nationally and in the College of Engineering (College) at TAMU increasing and diversifying engineering enrollments has become a focus, so that ethnicity and gender are of critical importance regarding measuring enrollment and retention of students. Nationally in 1998, enrollment percentages for first-time engineering undergraduates were: 80.4% male, 19.6% female; 69.1% White, 10% Asian, 8.5% Black, 7.4% Hispanic, and 0.8% Native American. In 1999, enrollment percentages were: 80.8% male, 19.2% female; 68.6% White, 10.2% Asian, 8.5% Black, 7.5% Hispanic, and 0.7% Native American [17]. Table 2 indicates the ethnicity, gender, and major of the students in this study. Demographic data for this study of first time enrolling students indicates they are predominantly White and male, which aligns with national first-year undergraduate engineering enrollment data for 1998 and 1999.

There were a greater number of African American females than African American males in the study population (17 females, 13 males), and a much larger number of Hispanic males than Hispanic females (69 males, 15 females). The study's African American population was the only ethnic group where females outnumbered males, though these numbers were not large. White males in this study outnumbered White females by more than five times (819 males, 153 females). White females were the largest ethnic group in the study's female population. There were 59 Asian males compared to 18 Asian females, and the Native American numbers were miniscule compared to any other ethnic group at less than .01% of the entire population with all of the Native American students being male.

**Table 2: Ethnicity and Gender by Engineering Major for Population**

<b>Ethnicity</b>	<b>*Computer</b>	<b>%</b>	<b>Electrical</b>	<b>%</b>	<b>Chemical</b>	<b>%</b>	<b>Mechanical</b>	<b>%</b>	<b>Civil</b>	<b>%</b>
<b>African Am.</b>	<b>13</b>	<b>5.2</b>	<b>6</b>	<b>3.0</b>	<b>4</b>	<b>1.9</b>	<b>4</b>	<b>1.1</b>	<b>3</b>	<b>2.2</b>
Female	2		3		1		1		1	
Male	11		3		3		3		2	
<b>Hispanic</b>	<b>21</b>	<b>8.4</b>	<b>8</b>	<b>3.9</b>	<b>12</b>	<b>5.6</b>	<b>31</b>	<b>8.6</b>	<b>12</b>	<b>8.8</b>
Female	4		1		6		4		2	
Male	17		7		6		27		10	
<b>White</b>	<b>183</b>	<b>72.9</b>	<b>173</b>	<b>85.2</b>	<b>178</b>	<b>83.6</b>	<b>316</b>	<b>87.5</b>	<b>121</b>	<b>88.3</b>
Female	17		24		56		37		20	
Male	166		149		122		281		101	
<b>Asian</b>	<b>34</b>	<b>13.5</b>	<b>15</b>	<b>7.4</b>	<b>19</b>	<b>8.9</b>	<b>8</b>	<b>2.2</b>	<b>1</b>	<b>.7</b>
Female	3		3		11		1		0	
Male	31		12		8		7		1	
<b>N. Am/other</b>	<b>0</b>		<b>1</b>	<b>.05</b>	<b>0</b>		<b>0</b>		<b>1</b>	<b>.7</b>
Female	0		0		0		0		0	
Male	0		1		0		0		1	
<b>Total</b>	<b>251</b>		<b>203</b>		<b>213</b>		<b>361</b>		<b>137</b>	

\*Computer Engineering has the greatest number of ethnic minorities

### Statistical Analysis

In this study, all tests of significance were two-tailed and non-directional since this research was exploratory and not “based on theoretical consideration or previous research” [18], and did not hypothesize in advance of data collection [19]. CBK completion is also termed progression to upper division status for engineering students in the TAMU data system, so the two terms are used inter-changeably in this study.

Three types of statistical analysis were used in this study: t-test, one-way ANOVAs, and product-moment correlation coefficient (Pearson’s  $r$ ). Mean ( $\mu$ ) and Standard Deviation ( $\sigma$ ) interval data are presented for all variables. Of the five independent variables, CGPA at time of completion of CBK is a continuous variable, with the remaining variables in the study being categorical: Ethnicity, Gender, Major, and Unmet Financial Need. Each measured variable under comparison requires a separate t-test.  $p$  values are also reported with an alpha of .05 throughout the data analysis. If results were statistically significant at the 0.05 level, then additional t-tests or ANOVAs were conducted to refine results.

Gender and Unmet Financial Need are true dichotomous variables, while Ethnicity and Engineering Major variables required dummy coding to be used in the regression analysis [20]. The variable for gender was coded 0 = male and 1 = female. The variable for Unmet Financial Need was created where 1= yes and 0= no. The variables ethnicity and major are nominally scaled, but not true dichotomous variable, as there are more than two options for ethnicity and major. In order to conduct statistical analysis, the researchers had to create an artificial dichotomy by coding each ethnicity and major of interest as “dummy variables.” This was accomplished by coding a variable as 1 for yes and 0 (zero) for all others not in that category. Further analysis had five data files by major being created and statistics conducted from each.

An initial t-test was conducted using Levene’s Test for Equality to find which category should be used: equal variance assumed or equal variance not assumed. In practice a t-test is typically used regardless of sample size. Conducting Levene’s Test for Equality with the t-tests ensures the assumption of equal variance for ANOVA is not violated.

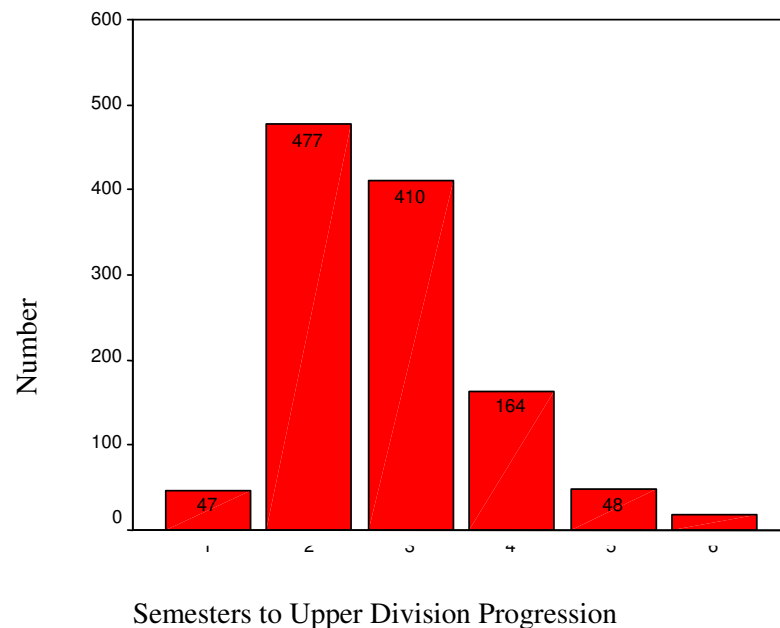
Effect size of  $R^2$  and adjusted  $R^2$  and beta weights are reported. Based on the review of the literature, this study also examined interaction effects for three variables: gender, underrepresented minority status, and unmet financial need.

## RESULTS

### Dependent Variable

Figure 1 indicates the number of semesters engineering students in the study took to progress to upper division status by completing CBK with the required cumulative grade point average (CGPA). The largest number of students 887, or 76%, completed CBK requirements and progressed to upper division status in either two or three semesters. These results align with the degree plans of the five TAMU Engineering majors in this study, which allocate approximately three semesters for completion of CBK.

**Figure 1: Number of Students per Semester Progression to Upper Division Status by Completion of CBK**



This study's effect size for all of the independent variables related to completion of CBK was a  $R^2$  of 0.193 (19.3%) with an adjusted  $R^2$  of 0.186 (18.6%). This indicates that factors other than the identified independent variables contribute approximately 80% to time to completion of CBK. The research literature for minority students indicates these other factors may include student motivation, academic preparation in high school, or other influences, such as transitioning to a new social setting and cultural environment [21-28].

### Analysis by Independent Variables

#### Ethnicity and time to completion of CBK

Data was coded 1 = minority (Hispanic, African American, Native American) and zero (0) = non-minority (White, Asian) with regard to student ethnic status. Table 3 indicates descriptive parameters for the two groups. The beta weight ( $\beta$ ) was 0.020 with an effect size of  $R^2$  of 0.011.

The adjusted  $R^2$  was 0.007. The variance in time to completion of CBK is greater for minority engineering students ( $\sigma = 1.019$ ) than for non-minority engineering students ( $\sigma = 0.98$ ).

**Table 3: Descriptive Parameters by Minority Status**

	N	Mean	$\sigma$
Minority	116	3.07	1.019
Non-minority	1049	2.75	0.98

Levene's Test for Equality for Minority and Non-Minority student status resulted in  $F = 0.242$  and  $p = 0.623$ , since there was no statistical significance, equal variances are assumed. **Results indicate a statistically significant difference at the 0.01 level ( $p = 0.001$ ) in mean time to completion of CBK between minority and non-minority students.** Since the t-test for minority or non-minority status was statistically significant ( $p = 0.001$ ) then further analysis by individual ethnic groups was warranted.

Data was disaggregated by ethnicity for descriptive and statistical analysis by ethnic group. Analysis of the data was performed by conducting t-tests for each of four ethnic groups: African American, Hispanic, Asian, and White. Table 4 indicates that Asian students finish CBK in the shortest time period ( $\mu = 2.73$  semesters) followed by White students ( $\mu = 2.75$  semesters).

**Table 4: Descriptive Parameters by Ethnicity**

Ethnicity	N	Mean	$\sigma$	p
African American	30	3.23	1.04	
Non-African American	1135	2.77	.98	
				0.011*
Hispanic	84	3.00	.99	
Non-Hispanic	1081	2.77	.99	
				0.036*
White	972	2.5	.97	
Non-White	193	2.90	1.08	
				0.020*
Asian	77	2.73	1.13	
Non-Asian	1088	2.79	.98	
				0.659

\*Significant at .05 level

African American students took the longest of the four ethnicities to complete CBK ( $\mu = 3.23$  semesters), and was the only ethnic group to have no individuals completing CBK in 1 semester. The White, Hispanic, and Asian ethnic groups all had individuals who completed CBK in 1 semester. The maximum number of semesters to complete CBK was six semesters for all four ethnic groups analyzed. The small number of Native American students ( $N = 2$ ) did not allow for accurate statistical analysis of that group, so data on Native American students were not analyzed.

Table 4 also includes p factors for the four ethnic groups. Levene's Test for Equality was conducted for African American engineering students compared to other non-African American ethnicities, and resulted in  $F = .007$  and  $p = 0.935$ , since there was no significance, equal variances are assumed resulting in statistical significance at the 0.05 level ( $p = 0.011$ ). Because

the variance is exactly equal for Hispanic and non-Hispanic students ( $\sigma = 0.99$ ), the equal variance assumption was met and results indicate a statistically significant difference at the 0.05 level ( $p = 0.036$ ) in the time to completion between Hispanic and non-Hispanic students. Levene's Test for Equality of White or non-White students resulted in  $F = 1.355$  and  $p = 0.245$ . Since there was not statistical significance, equal variances are assumed with results indicating statistical significance at the 0.05 level ( $p = 0.020$ ) for time to completion between White students and non-White students. Levene's Test for Equality of Asian or non-Asian students resulted in  $F = 4.930$  and  $p = 0.027$ ; therefore, since there was significance, equal variances are not assumed. Results indicate that there is not a significant difference ( $p = 0.659$ ) in the time to completion between Asian students and non-Asian students.

**Since African American, Hispanic, and White students showed statistical significance at the 0.05 level**, statistical analysis with t-tests were also conducted for comparison of the three groups. Table 5 indicates that African American students on the average take longer to complete CBK than Hispanic students,  $\mu = 3.23$  versus  $\mu = 3.00$  semesters.

**Table 5: Descriptive Parameters- African American-Hispanic Students**

	N	Mean	$\sigma$
African American	30	3.23	1.04
Hispanic	84	3.00	.99
<b>p = 0.278</b>			

Levene's Test for Equality of African American and Hispanic students resulted in  $F = .300$  and  $p = 0.585$ . Since there was no statistical significance, equal variances are assumed with results shown in Table 5 indicating *no statistical significance between African American and Hispanic students in time to completion of CBK* ( $p = 0.278$ ).

Table 6 indicates that African American students take longer to complete CBK than White students, 3.23 versus 3.00 semesters. Levene's Test for Equality of African American and White students resulted in  $F = .039$  and  $p = 0.844$ . Since there was no statistical significance, equal variances are assumed with results in Table 6 indicating *statistical significance at the 0.01 level* ( $p = 0.008$ ) for time to completion of CBK between African American and White students.

**Table 6: Descriptive Parameters- African American-White Students**

	N	Mean	$\sigma$
African American	30	3.23	1.04
White	972	2.75	.97
<b>p = 0.008**</b>			

Table 7 indicates that on the average Hispanic students ( $\mu = 3.00$  semesters) take longer to complete CBK than White students ( $\mu = 2.75$  semesters).

**Table 7: Descriptive Parameters- Hispanic and White Students**

	N	Mean	$\sigma$
Hispanic	84	3.00	0.99
White	972	2.75	0.97
<b>p = 0.025*</b>			

Levene's Test for Equality of Hispanic and White students resulted in  $F = 0.734$  and  $p = 0.392$ . Since there was no statistical significance, equal variances are assumed with results shown in Table 7 indicating *no statistical significance at the 0.05 level ( $p=0.025$ ) for time to completion of CBK between Hispanic and White students.*

### Ethnicity and Gender

Table 8 shows results of time to completion of CBK by gender, where Levene's Test for Equality resulted in  $F = .035$  and  $p = 0.852$ . Since Levene's didn't indicate significance, equal variances are assumed with results showing statistical significance at the .01 level ( $p = .008$ ).

**Table 8: Descriptive Parameters by Gender**

Gender	N	Mean	$\sigma$
Male	960	2.82	1.00
Female	205	2.61	.94

**p = 0.008**

Though this study does not create a predictor model, beta weights are reported for potential use by researchers in any future studies. The beta weight ( $\beta$ ) for gender was  $-.038$  with an effect size or  $R^2$  of  $.006$  and adjusted  $R^2$  of  $0.005$ . Since t-test results were statistically significant for three of the ethnic groups (African American, Hispanic, White) and for gender, further analysis is warranted related to ethnicity and gender.

Table 9 indicates the Descriptive Parameters for African American students in this study by gender. African American females are taking less time to complete CBK than African American males with less variance ( $\sigma = 0.866$ ) in their time to completion of CBK than males ( $\sigma = 1.198$ ).

**Table 9: Descriptive Parameters- African American Students by Gender**

African Am.	N	Mean	$\sigma$
Male	13	3.54	1.198
Female	17	3.00	.866

**p = 0.164**

Levene's Test for Equality of African American students and gender resulted in  $F = 2.713$  and  $p = 0.111$ . Since there was no statistical significance, equal variances are assumed with results indicating *no statistical significance ( $p=0.164$ ) for time to completion of CBK between African American males and females.*

Table 10 shows that Asian females are taking less time ( $\mu = 2.44$  semesters) to complete CBK than Asian males ( $\mu = 2.81$  semesters).

**Table 10: Descriptive Parameters- Asian Students by Gender**

Asian	N	Mean	$\sigma$
Male	59	2.81	1.106
Female	18	2.44	1.199

**p = 0.228**

Levene's Test for Equality of Asian students and gender resulted in  $F = 0.059$  and  $p = 0.809$ . Since there was no statistical significance, equal variances are assumed, with results indicating *no statistical significance* ( $p=0.228$ ) for time to completion of CBK between Asian males and Asian females.

Table 11 indicates Hispanic females are taking less time to complete CBK ( $\mu = 2.88$  semesters) than Hispanic males, who complete CBK on average in  $\mu = 3.03$  semesters.

**Table 11: Descriptive Parameters- Hispanic Students by Gender**

Hispanic	N	Mean	$\sigma$
Male	67	3.03	1.000
Female	17	2.88	.993

$p = 0.588$

Levene's Test for Equality of Hispanic students and gender resulted in  $F = .017$  and  $p = 0.898$ . Since there was no statistical significance, equal variances are assumed with results indicating *no statistical significance* ( $p=0.588$ ) for time to completion of CBK between Hispanic males and Hispanic females.

Table 12 indicates that White females are taking less time to complete CBK ( $\mu = 2.56$  semesters) than White males ( $\mu = 2.79$ ).

**Table 12: Descriptive Parameters- White Students by Gender**

White	N	Mean	$\sigma$
Male	819	2.79	.977
Female	153	2.56	.895

$p = 0.008^{**}$

Levene's Test for Equality for White students and gender resulted in  $F = .345$  and  $p = 0.557$ . Since there was no statistical significance, equal variances are assumed with results showing *statistical significance at the 0.01 level* ( $p=0.008$ ) for time to completion of CBK between White males and White females.

Ethnicity is a statistically significant factor in the completion of CBK or progression to upper level status at the 0.05 level for three of the four groups studied: African American ( $p = 0.011$ ), Hispanic ( $p = 0.036$ ), and White ( $p = 0.020$ ). Asian students as a whole completed CBK the fastest of all groups, but without statistical significance so the results could be attributed to chance. This is shown by a  $p$  value of 0.615, the largest of all four groups, where the higher  $p$  ( $p > .05$ ) value indicates a high probability of the results being obtained by chance.

The effect size of  $R^2$  of 0.011 an adjusted  $R^2$  of 0.007 for RQ2 indicates that though significant, ethnicity only contributes 1% or less to the relationship of all the variables in this study on time to completion of CBK.

### Ethnicity and Major

Table 13 indicates completion of CBK by major and ethnicity. A t-test was conducted for each major by ethnicity (minority or non-minority) to see if relationships existed. A data file was created for each major then t-test conducted by ethnicity with coding as 0 for non-minority and 1 for minority. Results are show in Tables 14 - 19. If statistical significance was found then further analysis was conducted related to specific ethnic groups. Empty cells or subcategories

without students in them (African American Computer Engineering majors taking 1, 5, or 6 semesters to complete CBK) do not impact statistical analysis because they are accounted for in the standard deviations.

**Table 13: CBK Completion by Major and Ethnicity**

	Semesters to Completion of CBK					
	1	2	3	4	5	6
<b>Computer Eng</b>	<b>6</b>	<b>80</b>	<b>110</b>	<b>36</b>	<b>12</b>	<b>7</b>
African Am.	0	6	6	1	0	0
Hispanic	0	1	12	3	4	1
White	6	59	81	25	6	6
Asian	0	14	11	7	2	0
Native Am	0	0	0	0	0	0
<b>Electrical Eng</b>	<b>5</b>	<b>94</b>	<b>70</b>	<b>21</b>	<b>11</b>	<b>2</b>
African Am.	0	0	2	3	0	1
Hispanic	0	5	3	0	0	0
White	5	81	61	18	7	1
Asian	0	8	4	0	3	0
Native Am	0	0	0	0	1	0
<b>Chemical Eng</b>	<b>18</b>	<b>103</b>	<b>57</b>	<b>27</b>	<b>5</b>	<b>3</b>
African Am.	0	0	3	1	0	0
Hispanic	2	3	3	3	1	0
White	12	91	49	20	4	2
Asian	4	9	2	3	0	1
Native Am	0	0	0	0	0	0
<b>Mechanical Eng</b>	<b>14</b>	<b>142</b>	<b>118</b>	<b>66</b>	<b>15</b>	<b>6</b>
African Am.	0	1	1	0	2	0
Hispanic	0	14	10	6	1	0
White	12	123	107	59	11	6
Asian	2	4	0	1	1	0
Native Am	0	0	0	0	0	0
<b>Civil Eng</b>	<b>4</b>	<b>58</b>	<b>55</b>	<b>14</b>	<b>5</b>	<b>1</b>
African Am.	0	0	2	0	1	0
Hispanic	0	3	6	3	0	0
White	4	54	46	11	4	1
Asian	0	0	1	0	0	0
Native Am	0	1	0	0	0	0
<b>Total</b>	<b>47</b>	<b>477</b>	<b>410</b>	<b>164</b>	<b>48</b>	<b>19</b>

Table 14 indicates the results of t-tests for the five engineering majors by ethnicity related to time to completion of CBK.

Levene's Test for Equality for Mechanical engineering minority and non-minority students resulted in  $F = .060$  and  $p = 0.806$ . Since there was no statistical significance with Levene's Test then equal variances are assumed and results indicate *no statistical significance* ( $t = -0.426$ ;  $p =$

0.670) related to time to completion of CBK between minority and non-minority Mechanical Engineering students.

**Table 14: Time to Completion of CBK by Major and Minority Status**

Major	N	Mean	$\sigma$	p
Mechanical Engineering				
Minority	35	2.91	0.98	
Non-Minority	326	2.84	1.017	
				0.670
Chemical Engineering				
Minority	16	2.94	1.124	
Non-Minority	197	2.53	0.977	
				0.117
Civil Engineering				
Minority	16	3.06	0.854	
Non-Minority	121	2.67	0.879	
				0.094
Computer Engineering				
Minority	34	3.24	1.017	
Non-Minority	217	2.91	0.944	
				0.080
Electrical Engineering				
Minority	15	3.20	1.207	
Non-Minority	188	2.69	0.920	
				0.046**

\*\* Significance found at the 0.05 level

Levene's Test for Equality for Chemical Engineering male and female students resulted in  $F = 0.091$  and  $p = 0.763$ . Since Levene's showed no statistical significance, then equal variances are assumed and results indicate *no statistical significance* ( $t = -1.575$ ;  $p = .117$ ) related to time to completion of CBK between minority and non-minority Chemical Engineering students.

Levene's Test for Equality for Civil Engineering minority and non-minority students resulted in  $F = 0.664$  and  $p = 0.417$ . Since there was no statistical significance with Levene's Test then equal variances are assumed and results indicate *no statistical significance* ( $t = 1.686$ ;  $p = 0.094$ ) related to time to completion of CBK between male and female Chemical Engineering students.

Levene's Test for Equality for Computer Engineering minority and non-minority students resulted in  $F = 0.092$  and  $p = 0.762$ . Since there was no statistical significance with Levene's Test then equal variances are assumed. *No statistical significance was found* ( $t = -1.756$ ;  $p = .080$ ) related to time to completion of CBK between minority and non-minority Computer Engineering students.

Levene's Test for Electrical Engineering majors by minority or non-minority status resulted in  $F = 1.624$  and  $p = 0.204$ . Since there was no statistical significance with Levene's Test, equal variances are assumed. Since *statistical significance was found at the 0.05 level* ( $t = -2.011$ ;  $p = 0.046$ ) in relationships of time to CBK completion and minority status for electrical engineering majors, then further analysis is warranted.

Due to the results of the t-test showing statistical significance for Electrical Engineering majors, a one-way ANOVA was conducted to determine if time to completion of CBK differed significantly for Electrical Engineering majors by Ethnicity. Results are indicated in Table 15 with statistical significance found at the 0.01 level ( $p = 0.001$ ).  $R^2$  was 0.091 with adjusted  $R^2$  of 0.073 indicating that ethnicity accounted for approximately 9% (7% adjusted) in time to completion of CBK for electrical engineering students.

**Table 15: ANOVA<sup>b</sup> for Electrical Engineering and Ethnicity**

	DF	SS	MS	F	Sig.
Regression	4	16.617	4.154	4.971	.001 <sup>a**</sup>
Residual	198	165.481	0.836		
Total	202	182.099			

a Predictors: (Constant), Hispanic, African American, Asian, White

b Dependent variable: Semester to CBK completion

\*\* Statistical Significance was found at 0.01 level

Table 16 shows statistical significance found at the 0.05 level for Electrical Engineering majors who are Asian ( $p = 0.025$ ) students and White ( $p = 0.012$ ) students, and at the 0.01 level for and Hispanic ( $p = 0.007$ ) students. This indicates that TAMU Electrical Engineering students from these three ethnic groups have a statistically significant relationship to time to completion of CBK. Table 16 indicates the beta weights ( $\beta$ ) and coefficients for the, which are reported for potential use by researchers in any future studies.

**Table 16: Coefficients<sup>a</sup> Electrical Engineering Majors**

	Unstandardized		Standardized		Sig. (p)
	Coefficients		Coefficients		
	B	Std. Error	Beta	t	
(Constant)	5.000	.914		5.469	.000
African Am	-1.000	.987	-.170	-1.013	.312
Asian	-2.133	.944	-.589	-2.259	*.025
White	-2.324	.917	-.871	-2.534	*.012
Hispanic	-2.625	.970	-.539	-1.707	** .007

a Dependent variable: Semester to CBK completion

\* Statistical Significance at 0.05 level

\*\* Statistical Significance at the 0.01 level

### Unmet Financial Need and Ethnicity

A study by Bresciani and Carson [29] finds that the financial aid calculation of unmet financial need is a predictor of student persistence. Thus influencing the use in this study of defining the relationship of time to completion based on student unmet financial need [30].

This study analyzed parameters by minority versus non-minority student status prior to disaggregating between ethnicity groups and unmet financial need (UFN). Levene's Test for Equality of the variables ethnicity and UFN related to completion of CBK resulted in  $F = 0.205$  and  $p = .651$ . Since no statistical significance was found, equal variances are assumed with results finding statistical significance at the 0.01 level ( $p = 0.001$ ) for UFN related to time to completion of CBK. Therefore, further analysis is merited for UFN by individual ethnicities.

Table 17 shows descriptive statistics for unmet financial need by ethnicity. Native American students have the lowest of UFN and highest number of semesters to complete CBK of students with UFN. However, their numbers are so small that results for this category are not considered to be accurate for this study and are not displayed in subsequent tables and analysis. Underrepresented minority students (Hispanic, African American) have a larger number of students with UFN than not having UFN.

Students taking the longest number of semesters to complete CBK are those with UFN who are African American ( $\mu = 3.35$  semesters;  $\sigma = 1.00$ ) and Hispanic ( $\mu = 3.22$  semesters;  $\sigma = 1.08$ ) students. African American students without UFN ( $\mu = 3.08$  semesters;  $\sigma = 1.12$ ) are also taking just slightly longer than the median completion rate of 3 semesters. All of the other ethnic groups in this study, with the exception of Native Americans, are taking 3.0 or less semester to complete CBK regardless of having or not having UFN. Of those with no UFN, the ethnic group with the greatest variance is African American ( $\sigma = 1.12$ ) with Hispanics being the group with the least variance ( $\sigma = 0.89$ ). For students with UFN, the variance in time to completion of CBK ranges from Asian ( $\sigma = 1.35$ ) to White students ( $\sigma = 0.93$ ).

**Table 17: Demographic Statistics for UFN by Ethnicity**

<b>No UFN</b>			
<b>Ethnicity</b>	<b>Frequency</b>	<b>Mean</b>	<b><math>\sigma</math></b>
Asian	53	2.60	1.01
African American	13	3.08	1.12
Hispanic	47	2.83	0.89
Native American*	1	2.00	0.00
White	811	2.73	0.97
<b>Total</b>	<b>925</b>	<b>2.73</b>	<b>0.97</b>
<b>Having UFN</b>			
<b>Ethnicity</b>	<b>Frequency</b>	<b>Mean</b>	<b><math>\sigma</math></b>
Asian	24	3.00	1.35
African American	17	3.35	1.00
Hispanic	37	3.22	1.08
Native American*	1	5.00	0.00
White	161	2.87	0.93
<b>Total</b>	<b>240</b>	<b>2.98</b>	<b>1.02</b>

\* Number too small for accurate calculation

The majority of students (81%) in this study do not have UFN. UFN had a statistically significant relationship to time to completion of CBK ( $p = .001$ ), indicating that this factor impacts the length of time a student with need takes to progress to upper level status. It would be assumed that this will also impact time to ultimate progression toward degree or graduation. However, the effect size was very small (adjusted  $R^2$  of 0.009) indicating that the UFN variable contributes little to the overall time to completion of CBK.

A one-way ANOVA was conducted for each of the four ethnic groups as to having or not having UFN as it relates to time to complete CBK and progress to upper division status in the College of Engineering. Coding for ethnicity was 2=Asian; 3=African American; 4=Hispanic; 5= Native American; and 6= White. Due to the small number of Native Americans, an ANOVA was not conducted for this ethnic group.

Table 18 indicates the one-way ANOVA results for UFN and students by ethnicity with relationship to CBK. *UFN by ethnicity did not result in findings that were statistically significant at either the 0.01 or 0.05 levels.* Correlation between minority status and time to completion of CBK for no UFN was  $r = 0.005$  and for UFN  $r = -0.117$  indicating very little correlation between UFN and minority/non-minority student status.

**Table 18: ANOVA for UFN by Ethnicity<sup>a,b</sup>**

	DF	SS	MS	F	Sig.
<b>Asian<sup>c</sup></b>					
Regression	1	2.593	2.593	2.054	0.156 <sup>a</sup>
Residual	75	94.679	1.262		
Total	76	97.273			
<b>African Am.<sup>d</sup></b>					
Regression	1	.561	.561	.510	0.481 <sup>a</sup>
Residual	28	30.805	1.100		
Total	29	31.367			
<b>Hispanic<sup>e</sup></b>					
Regression	1	3.091	3.091	3.213	0.077 <sup>a</sup>
Residual	82	78.909	0.962		
Total	83	82.000			
<b>White<sup>f</sup></b>					
Regression	1	2.664	2.664	2.851	.092 <sup>a</sup>
Residual	970	906.581	0.935		
Total	971	909.246			

- Predictors: (Constant), Unmet Financial Need
- Dependent variable: Semester to CBK completion
- Selecting only cases for which Ethnicity = Asian
- Selecting only cases for which Ethnicity = African American
- Selecting only cases for which Ethnicity = Hispanic
- Selecting only cases for which Ethnicity = White

The beta weight ( $\beta$ ) for UFN and Asian students for time to completion of CBK was .0163, and effect size of  $R^2$  was 0.027 with an adjusted  $R^2$  of 0.014 indicating that this combined grouping represented less than 2% as a combination of factors of time to CBK completion. No statistical significance was found ( $t = 1.433$ ,  $p = 0.156$ ).

The beta weight ( $\beta$ ) for UFN and African American students for time to completion of CBK was 0.134, and effect size or  $R^2$  was .018 with an adjusted  $R^2$  of 0.017 indicating that this combined grouping of variables represents a contribution of approximately 2% as a combination of factors in time to CBK completion. No statistical significance was found ( $t = 0.714$ ,  $p = 0.481$ ).

The beta weight ( $\beta$ ) for UFN and Hispanic students for time to completion of CBK was 0.194, and effect size or  $R^2$  was 0.038 with an adjusted  $R^2$  of 0.026 indicating that this combined grouping represented a contribution of almost 4% as a combination of factors in time to CBK completion. No statistical significance was found ( $t = 1.792$ ,  $p = 0.077$ ).

Beta weight ( $\beta$ ) for UFN and White students for time to completion of CBK was 0.054, and effect size or  $R^2$  was 0.003 with an adjusted  $R^2$  of 0.002 indicating that this combined

relationship represented a contribution of less than 1% (0.2%) as a combination of factors in time to CBK completion. No statistical significance was found ( $t = 1.688$ ,  $p = 0.092$ ).

### Cumulative Grade Point Average and Ethnicity

For all students in the population, Table 22 indicates that the mean CGPA at time of progression to upper level status was 3.0191 with a standard deviation ( $\sigma$ ) of 0.53283.

**Table 19: Frequency, Mean and Standard Deviation ( $\sigma$ ) of Population for Time to Completion by Cumulative GPA**

	N	Minimum	Maximum	Mean	$\sigma$
CGPA at time of CBK completion	1165	1.05	4.0	3.0191	0.53283

Figure 2 indicates the mean cumulative grade point average (CGPA) by semester of time to completion of CBK. This figure shows that students who on average have a higher CGPA are completing CBK in less time than those with lower CGPA, with the exception of students completing CBK in five semesters.

**Figure 2: CGPA at Time of Completion of CBK**

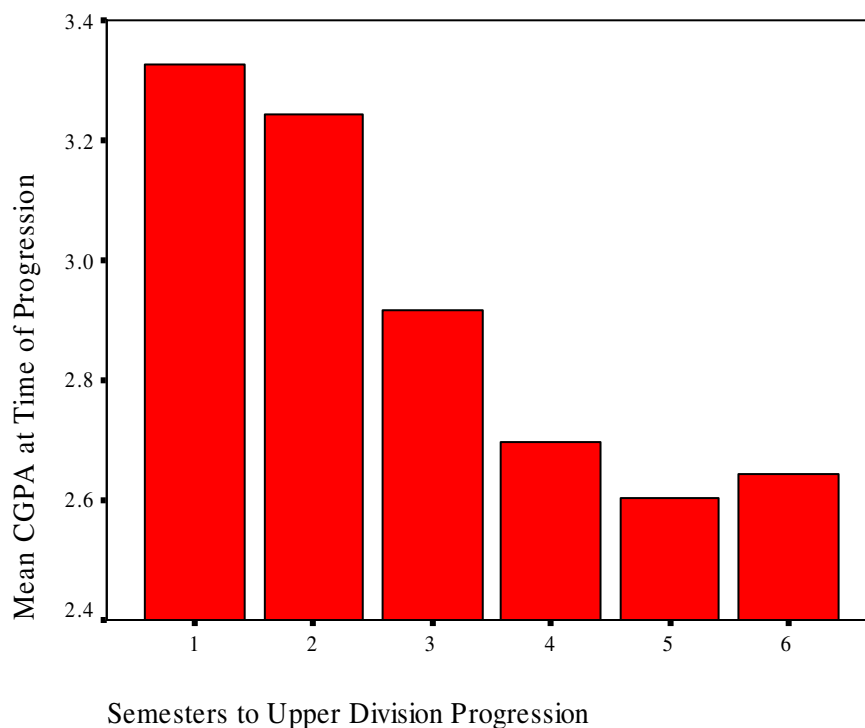


Table 20 indicates results of the relationship of CGPA to time to completion are statistically significant at the 0.01 level, with a strong correlation ( $r = -0.408$ ,  $p = 1.2 \times 10^{-22}$ ). Results indicate almost no probability ( $p = 1.2 \times 10^{-22}$ ) that the statistical result was obtained by chance, with the correlation for the relationship of CGPA to time to completion of CBK being very strong. The

negative  $r$  indicates that the higher the CGPA the less number of semesters an engineering student takes to complete CBK.

**Table 20: Multiple Regression and p values by CGPA**

	Pearson's $r$	p value	Significance
CGPA	-0.408	$1.2 \times 10^{-22}$	0.01**

\*\* Statistical Significance at the 0.01 level

Since CGPA was found to be statistically significant, further statistical analyses were conducted for CGPA at time of CBK completion by gender, ethnicity, UFN, and student major as shown in Table 21. The lowest CGPA across all categories was less than a 2.00, ranging from a low of 1.05 for a Mechanical Engineering major and 1.92 for an Electrical Engineering major. By ethnic group, there were no African American students who had a 4.00 CGPA, the lowest mean CGPA was 2.4630 for Hispanic students, and the highest mean of 3.0519 was for White students. Minority students (African American  $\mu = 2.657$ ,  $\sigma = 0.4736$ ; and Hispanic  $\mu = 2.4630$ ,  $\sigma = 0.5805$ ) had lower mean CGPA than non-minority (White  $\mu = 3.0519$   $\sigma = 0.5225$ , and Asian  $\mu = 2.9403$ ,  $\sigma = 0.5476$ ) students did.

**Table 21: CGPA at CBK Completion by Gender, Ethnicity, UFN, and Major**

	Lowest	Highest	Mean	Std. Deviation
<b>Gender</b>				
Male	1.05	4.00	3.0028	0.5279
Female	1.60	4.00	3.0950	0.5503
<b>Ethnicity</b>				
African Am	1.75	3.87	2.6577	0.4736
Hispanic	1.74	4.00	2.4630	0.5805
White	1.05	4.00	3.0519	0.5225
Asian	1.43	4.00	2.9403	0.5476
<b>Financial Need</b>				
No UFN	1.05	4.00	3.0409	0.5413
UFN	1.52	4.00	2.9348	0.4910
<b>Major</b>				
Computer	1.60	4.00	3.0569	0.5177
Electrical	1.92	4.00	3.0409	0.5185
Chemical	1.79	4.00	3.1233	0.5172
Mechanical	1.05	4.00	2.9799	0.5522
Civil	1.74	4.00	2.8584	0.5133

The variable CGPA is responsible for over 16% ( $R^2$ , 0.167; adjusted  $R^2$  of 0.166) of the total 19% effect size ( $R^2$ ) of all the variables in this study related to time to completion of CBK. The beta weight ( $\beta$ ) was 0.404 with an effect size of  $R^2$  of 0.167 and adjusted  $R^2$  of 0.166 and again is presented for use by researchers who may conduct similar studies.

### Correlations

Table 22 shows results of statistical correlations related to time to CBK completion by gender, ethnicity, UFN, and major. All correlations for categories by gender, ethnicity, UFN,

and major had negative Pearson's  $r$ , indicating that on average, the higher a student's CGPA, the fewer semesters needed to complete CBK, also related to Figure 4. These correlations were statistically significant at the 0.01 level for every subgroup except for African American ( $p = 0.108$ ).

**Table 22: Correlations for CGPA for CBK Completion by Gender, Ethnicity, UFN, and Major**

	Pearson R	P value
<b>Gender</b>		
Male	-0.404	<0.01**
Female	-0.414	<0.01**
<b>Ethnicity</b>		
<b>African American</b>	<b>-0.299</b>	<b>0.108</b>
Hispanic	-0.489	<0.01**
White	-0.408	<0.01**
Asian	-0.292	0.010**
<b>Financial Need</b>		
No unmet need	-0.407	<0.01**
Unmet need	-0.391	<0.01**
<b>Major</b>		
Computer	-0.303	<0.01**
Electrical	-0.055	<0.01**
Chemical	-0.493	<0.01**
Mechanical	-0.440	<0.01**
Civil	-0.264	0.002**

\*\*Statistically significant at 0.01 level

## CONCLUSIONS & RECOMMENDATIONS

*Underrepresented minority (African American, Hispanic) engineering students take a statistically significant longer time to complete CBK as compared to non-minority students with significance at the 0.01 level* ( $p = 0.001$ ) in mean time to completion of CBK. This is substantiated by the finding of statistical significance at the 0.01 level ( $p = 0.008$ ) for time to completion of CBK between African American and White students, and at the 0.05 level between Hispanic and White students. No statistical significance was found between African American and Hispanic students in time to completion of CBK ( $p = 0.278$ ).

A review of descriptive parameters for the entire population of all students completing CBK indicates substantial disparities between mean time to completion for minority versus non-minority students. There may be a potential disparate impact attributed to the requirement of set GPAs for progression that do not prevent minority students from completing CBK but cause them to take longer to do so. Several research findings indicate underrepresented minority students come to engineering programs less prepared than their non-minority counterparts. With this being known, and diversity presently being a focused recruitment effort of TAMU, it may benefit the College to address these findings to ensure broader success of first-year underrepresented minority students accepted to TAMU.

*Statistical significance was found for women taking less time than males to complete CBK.* Statistical significance was found at the 0.01 level ( $p = 0.008$ ) for time to completion of CBK with

White females completing CBK in less time than White males. Statistical significance was not found in the relationship underrepresented minority students by gender to CBK completion.

***Electrical Engineering was the only major found to have statistical significance at the 0.05 level ( $p = .046$ ) for minority status with minority students taking a longer time to complete CBK*** ( $\mu = 3.20$  semesters for minority versus  $\mu = 2.69$  semesters for non-minority). Statistical significance for ethnic groups within Electrical Engineering majors was found at the 0.05 level for Asian ( $p = 0.025$ ) and White ( $p = 0.012$ ) students, and at the 0.01 level for Hispanic students ( $p = 0.007$ ). This indicates that being Asian, White or Hispanic as an Electrical Engineering major has a relationship to time to completion of CBK with those ethnicities completing CBK in less time.

***Having unmet financial need (UFN) statistically relates to and increases the time necessary to complete CBK at the 0.01 level ( $p = 0.001$ ).*** In this study, underrepresented minority students with UFN are taking longer to complete CBK than non-minority students with UFN, but statistical significance was not found. Increased time to complete CBK may be attributed to a greater need to work while enrolled in college for those with UFN. Implications due to analysis of the entire populations for 1998 and 1999 are relevant even if statistical significance was not found.

***CGPA has a statistically significant relationship at the 0.01 level to time to complete CBK and progression to upper level division status, with a higher CGPA indicating less time to complete CBK.*** This variable had the strongest correlation and effect size, being responsible for 16% of the total 19% effect size contributed by the variables used in this study. Departments in the College of Engineering at TAMU should review mechanism to support students accepted to the college and consider the impact of additional time for minority students as having potential for disparate impact based on higher CGPA requirements.

## **Future Research**

Researchers of this study have obtained data on graduation of the 1998 and 1999 cohorts of students used in this study and will be conducting another study indicating the relationship of time to completion of CBK with regard to graduation. Analysis of minority students (Hispanic and African American) time to completion of CBK compared to time to degree completion will be made to see if once they complete CBK they remain in the pipeline and complete an engineering degree. Also the study will review the question if UFN has a relationship to cumulative grade point average or overall degree completion for minority engineering majors.

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