

## The gender effect on academic success among first-generation engineering undergraduate (FGEU) students

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**ABSTRACT:** Most existing research on first-generation college students focuses on their overall college experience and challenges. Research on first-generation engineering undergraduate (FGEU) students is lacking, especially comparing academic success between male and female FGEU students. Research on this latter topic is critical as it directly addresses engineering retention and graduation. To fill this important research gap, the present study conducts a quantitative analysis to investigate the effect of gender on academic success among FGEU students. Data regarding students' college grade point average (GPA) and American College Testing (ACT) scores in three academic years were collected, involving 977 FGEU students (848 males and 129 females) at a public research institution in the U.S. The ACT is a standardised, high-stakes examination for college admission in the U.S., and includes ACT composite, English, mathematics, reading and science scores. A statistical analysis was performed on the collected data. The results show that the correlation between college GPA and ACT scores is statistically significant for male FGEU students but not statistically significant for female FGEU students. This new research finding has a practical significance when analysing the college performance of FGEU students or developing a mathematical model to predict their college academic performance.

**Keywords:** First-generation engineering undergraduates, the gender effect, academic success, quantitative study

### INTRODUCTION

First-generation college students are generally defined as those undergraduates whose parents' highest level of education is a high school diploma or less, or whose parents have never enrolled in postsecondary education [1]. Statistical data from the U.S. Department of Education [1] shows that, on average, 43% of students at various institutions of higher learning in the U.S. are first-generation college students. First-generation students constitute a significant portion of college student body in both developed and developing countries worldwide [2].

Existing research shows that compared to continuing-generation students, first-generation students have unique challenges in their college studies [3][4]. As many of them come from low-income families with economic challenges in daily life, they receive little or no assistance from their parents in terms of academic guidance and career and consultation [5-7]. Existing research also shows that compared to continuing-generation students, many first-generation students possess lower self-efficacy and engage less with other students and the instructor [8-11]. In the science, technology, engineering and mathematics (STEM) fields, the grade point average (GPA) of first-generation students is 0.15 points lower than that of continuing-generation students, with a 6% less likelihood of graduating from college [12-14]. Therefore, studies - like the present study - that focus on the academic success of first-generation students have always been important due to their significant impacts on the issues and problems that first-generation students have faced.

Moreover, an extensive literature review using popular databases; for example, Scopus, ERIC, ScienceDirect and the Web of Science, shows that most existing research on first-generation students focuses on their overall college experience and challenges [12-19]. Research on first-generation engineering undergraduate (FGEU) students is still lacking, especially comparing academic success between male and female FGEU students. Engineering, although part of STEM fields, has its unique features as engineering (E) focuses on applying science (S), technology (T) and mathematics (M) to solve real-world problems. Students must have a solid understanding of science, mathematics, and relevant technology tools to learn engineering better.

Research on FGEU students is critical as it directly addresses engineering retention and graduation, which are long-standing problems in many engineering schools [17]. As an increasing number of female students enter engineering schools [20-23], educators must understand the effect of gender to develop subsequent educational interventions to improve engineering retention and graduation for both male and female students.

The present study aims to investigate the effect of gender on academic success among FGEU students to address the above-described research gaps. In this article, the author introduces four research questions of the present study, followed by a description of the research method. What and how data was collected is described, followed by statistical descriptive, *t*-test and correlation analyses. The results of the research findings are discussed. The limitations of the present study are also described. Conclusions are made at the end of this article.

## RESEARCH QUESTIONS

The present study has the following four research questions:

1. Is there a statistically significant difference in college grade point average (GPA) scores between male and female FGEU students?
2. Is there a statistically significant difference in American College Testing (ACT) scores between male and female FGEU students?
3. Is there a statistically significant correlation between college GPA and ACT scores for male and female FGEU students?
4. Is there a statistically significant correlation among ACT scores for male and female FGEU students?

In the present study, college GPA is the cumulative GPA a student earned at the end of an academic year (AY) in his/her undergraduate study. The ACT is a standardised, high-stakes examination the U.S. College Board administers to assess high school students' academic preparation for college admission [24][25]. ACT scores include ACT composite, English, mathematics, reading and science scores. Many engineering schools at higher education institutions require a minimum ACT score for incoming engineering undergraduates.

## RESEARCH METHOD

Quantitative statistical analysis was performed to answer the above-described four research questions [26]. Specifically, *t*-tests were conducted to answer the first two research questions, and correlation analysis was performed to answer the last two research questions.

## DATA COLLECTION

The data collected in the present study included FGEU students' college GPA, and ACT composite, English, mathematics, reading and science scores. Before data collection and analysis, an Institutional Review Board approval for the present human-subject research was secured. Relevant staff was contacted to extract data from the institutional database. All data employed in the present study was anonymous to ensure the privacy and confidentiality of study participants (i.e. FGEU students). The students with missing data were excluded from the present study.

As a result, a total of 977 FGEU students from a public research institution in the Northern Rocky Mountain area in the U.S. were included in the present study. These students have complete data in the institutional database. They were from four engineering departments in the institution: Biological Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, and Mechanical and Aerospace Engineering.

Table 1 shows the number of male and female FGEU students in three academic years involved in the present study. The 977 FGEU students included 848 males and 129 females. This high male-to-female ratio (6.5:1) is typical in engineering schools in the U.S.

Table 1: Number of FGEU students involved in the present study.

Academic year (AY)	Male	Female	Total
AY I	304	43	347
AY II	299	45	344
AY III	245	41	286

## RESULTS AND ANALYSIS

### Descriptive Statistics

Table 2 shows the results of descriptive statistics, including mean and standard deviation (SD). As can be seen from Table 2, the mean values and standard deviations of college GPA and ACT scores are close between male and female FGEU students in most cases in three academic years. For example, in academic year II, the mean value of college GPA is 3.15 for males and 3.35 for females, while the standard deviation is 0.67 and 0.33, respectively, for males and females. In a few cases, the standard deviation of ACT scores for females is less than that for males; for example, ACT science scores in academic year III. This implies that the variation of ACT science scores for females is less than that of males.

Table 2: Results of descriptive statistics.

Academic scores	Gender	Academic year I		Academic year II		Academic year III	
		Mean	SD	Mean	SD	Mean	SD
College GPA	Male	3.19	0.55	3.15	0.67	3.17	0.70
	Female	3.19	0.56	3.35	0.33	3.32	0.57
ACT composite	Male	25.47	4.42	25.42	4.37	25.69	4.39
	Female	25.26	4.52	26.07	4.15	25.88	4.04
ACT English	Male	24.36	5.44	24.30	5.34	24.74	5.41
	Female	25.47	5.75	26.62	5.39	26.15	5.34
ACT mathematics	Male	26.15	4.67	26.09	4.74	26.41	4.61
	Female	25.30	4.12	26.02	3.70	26.24	3.83
ACT reading	Male	25.93	5.60	25.71	5.45	25.85	5.50
	Female	26.12	5.61	26.09	4.74	26.73	5.28
ACT science	Male	26.15	4.53	26.31	4.54	26.58	4.59
	Female	24.95	4.63	25.69	4.31	25.56	3.68

### Results of *T*-Tests

*T*-tests were performed to determine if there is a statistically significant difference in college GPA and ACT scores between male and female FGEU students. Table 3 shows the results. Based on the two-sided *p*-values listed in Table 3, except for ACT English scores in academic year II, male and female FGEU students have no statistically significant difference in college GPA, ACT composite, English, mathematics, reading and science scores.

Table 3: Results of independent samples *t*-tests on FGEU students' academic success.

Academic success indicators	Academic year I		Academic year II		Academic year III	
	<i>t</i>	<i>p</i> -value	<i>t</i>	<i>p</i> -value	<i>t</i>	<i>p</i> -value
College GPA	0.072	0.943	1.875	0.062	1.239	0.216
ACT composite	-0.302	0.763	0.924	0.356	0.262	0.793
ACT English	1.240	0.216	2.719	0.007	1.540	0.125
ACT mathematics	-1.131	0.259	-0.088	0.930	-0.221	0.825
ACT reading	0.199	0.842	1.564	0.119	0.952	0.342
ACT science	-1.614	0.107	-0.863	0.389	-1.349	-1.349

### Statistical Correlation Analysis

Statistical correlation analysis was further performed to determine if there is a statistically significant correlation between college GPA and ACT scores for male and female FGEU students. Table 4 and Table 5 show the results. Table 4 shows a statistically significant correlation between college GPA and ACT scores for male FGEU students in all three academic years.

However, as shown in Table 5, there is no statistically significant correlation between college GPA and ACT scores for female FGEU students in all three academic years. The only exception is the statistically significant correlation between college GPA and ACT English scores ( $p < 0.05$ ) for female FGEU students in academic year II. These new and original research findings have not been reported in existing literature.

Table 4: Correlation between cumulative GPA and ACT scores for male FGEU students.

Academic year (AY)	Correlation	ACT composite	ACT English	ACT mathematics	ACT reading	ACT science
AY I	Pearson correlation	0.376**	0.344**	0.365**	0.300**	0.338**
AY I	<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	<0.001
AY II	Pearson correlation	0.373**	0.342**	0.389**	0.266**	0.330**
AY II	<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	<0.001
AY III	Pearson correlation	0.227**	0.212**	0.222**	0.222**	0.148*
AY III	<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	0.021

\*Correlation is significant at the 0.05 level (2-tailed)

\*\*Correlation is significant at the 0.01 level (2-tailed)

Table 5: Correlation between cumulative GPA and ACT scores for female FGEU students.

Academic year (AY)	Correlation	ACT composite	ACT English	ACT mathematics	ACT reading	ACT science
AY I	Pearson correlation	0.206	0.261	0.209	0.200	0.128
AY I	<i>p</i> -value	0.185	0.092	0.179	0.198	0.414
AY II	Pearson correlation	0.255	0.350*	0.170	0.253	0.224
AY II	<i>p</i> -value	0.091	0.018	0.265	0.094	0.139
AY III	Pearson correlation	0.115	0.179	0.172	0.106	0.128
AY III	<i>p</i> -value	0.475	0.262	0.284	0.511	0.425

\*Correlation is significant at the 0.05 level (2-tailed)

Statistical correlation analysis was also performed to determine if there is a statistically significant correlation among ACT scores for male and female FGEU students. Table 6 and Table 7 show the results, using academic year I as an example. As can be seen from Table 6 and Table 7, a statistically significant correlation exists among ACT scores for both male and female students. This research finding applies to academic years II and III as well.

Table 6: Correlation among ACT scores for male FGEU students: academic year I as an example.

Academic success indicators	Correlation	ACT composite	ACT English	ACT mathematics	ACT reading	ACT science
ACT composite	Pearson correlation	1	0.913**	0.842**	0.886**	0.894**
	<i>p</i> -value		<0.001	<0.001	<0.001	<0.001
ACT English	Pearson correlation	0.913**	1	0.699**	0.788**	0.741**
	<i>p</i> -value	<0.001		<0.001	<0.001	<0.001
ACT mathematics	Pearson correlation	0.842**	0.699**	1	0.626**	0.755**
	<i>p</i> -value	<0.001	<0.001		<0.001	<0.001
ACT reading	Pearson correlation	0.886**	0.788**	0.626**	1	0.739**
	<i>p</i> -value	<0.001	<0.001	<0.001		<0.001
ACT science	Pearson correlation	0.894**	0.741**	0.755**	0.739**	1
	<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	

\*\*Correlation is significant at the 0.01 level (2-tailed)

Table 7: Correlation among ACT scores for female FGEU students: academic year I as an example.

Academic success indicators	Correlation	ACT composite	ACT English	ACT mathematics	ACT reading	ACT science
ACT composite	Pearson correlation	1	0.930**	0.920**	0.913**	0.916**
	<i>p</i> -value		<0.001	<.0001	<0.001	<0.001
ACT English	Pearson correlation	0.930**	1	0.816**	0.828**	0.792**
	<i>p</i> -value	<0.001		<0.001	<0.001	<.001
ACT mathematics	Pearson correlation	0.209	0.920**	0.816**	1	0.750**
	<i>p</i> -value	0.179	<0.001	<0.001		<0.001
ACT reading	Pearson correlation	0.913**	0.828**	0.750**	1	0.803**
	<i>p</i> -value	<0.001	<0.001	<0.001		<0.001
ACT science	Pearson correlation	0.916**	0.792**	0.867**	0.803**	1
	<i>p</i> -value	<0.001	<0.001	<0.001	<0.001	

\*\*Correlation is significant at the 0.01 level (2-tailed)

## DISCUSSIONS

College GPA is a comprehensive measure of a student's academic performance in college [27]. ACT scores represent a student's academic performance before entering college. The above-described *t*-test results show that male and female FGEU students have no statistically significant difference in college GPA and various ACT scores. It should be noted that this research finding was generated only from the FGEU students involved in the present study.

However, the most interesting research finding from the above-described correlation analysis is that a statistically significant correlation between college GPA and ACT scores exists for male FGEU students but does not exist for female FGEU students. This research finding implies that pre-college ACT scores are important in affecting male FGEU students' college GPA but not critical in affecting female FGEU students' college GPA.

A student's college GPA is affected by numerous factors, including cognitive factors (such as intellectual abilities reflected by mathematical skills, reading skills, etc) and many non-cognitive factors; for example, sense of belonging, motivation, self-confidence and self-efficacy [28]. Research has shown that non-cognitive factors significantly affect female students' academic performance [29]. Therefore, the effect of non-cognitive factors on college GPA can be substantially higher than the effect of ACT scores for female FGEU students. This explains why no statistically significant correlation between college GPA and ACT scores is found for female FGEU students.

The research finding that the correlation between college GPA and ACT scores is statistically insignificant for female FGEU students has a practical significance. When analysing the college performance of female FGEU students or developing a mathematical model to predict their college performance, educators should not put too much weight on their ACT scores. Instead, the above-mentioned non-cognitive factors should receive more consideration.

## LIMITATIONS OF THE PRESENT STUDY

The present study has two limitations. First, all data employed was collected from a single institution rather than multiple institutions. As each institution is different in teaching, learning, environment and student characteristics, the research findings generated from the present study will be more statistically robust if multiple institutions are involved. Second, although the present study included nearly 1,000 FGEU students, only 13.2% were females. The ratio of male to female FGEU students is 6.5:1. This is typical in the U.S. as male students are still dominant in U.S. engineering schools. In the present research it would be desirable if more female students were included.

## CONCLUSIONS

This article has described the results of a quantitative study of the effect of gender on academic success among first-generation engineering undergraduate (FGEU) students. Based on the data collected from 977 FGEU students (848 males and 129 females) and associated *t*-test analysis, it is found that male and female FGEU students have no statistically significant difference in college GPA, ACT composite, English, mathematics, reading and science scores.

The results of statistical correlation analysis show that a statistically significant correlation between college GPA and ACT scores exists for male FGEU students but does not exist for female FGEU students. This new research finding suggests that pre-college ACT scores are important in affecting male students' college GPA but not critical in affecting female students' college GPA. This research finding has a practical significance when analysing the college performance of FGEU students or developing a mathematical model to predict their college performance.

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