International Journal of Engineering Education Vol. 37, No. 5, pp. 1161–1173, 2021
Printed in Great Britain
0949-149X/91 $3.00+0.00

A Non-Parametric Statistical Analysis of the Relationship Between College GPA and ACT Scores for First- and Continuing-Generation Engineering Undergraduates*

NING FANG
Department of Engineering Education, College of Engineering, Utah State University, 4160 Old Main Hill, Logan, UT 84322, USA.
E-mail: ning.fang@usu.edu

A significant portion of college students are first-generation students – whose parents' highest level of education is a high school diploma or less, or whose parents have never enrolled in postsecondary education. The present study investigates the relationship between first- and continuing-generation undergraduate engineering students' college graduate point average (GPA) and ACT scores across all four years of undergraduate study, rather than solely the first year. ACT (American College Testing) is a standardized test administered by the College Board and widely used for college admission in the U.S. The data employed in the present study were collected from a 4-year public research institution in the U.S., involving 6,683 student records in recent three academic years. These student records included 977 (14.6%) records for first-generation students and 5,706 (85.4%) records for continuing-generation students. Based on the results of normality tests, non-parametrical statistical analysis was performed in the present study. It was found that in general, the difference in college GPA between first- and continuing-generation students is not statistically significant, while the difference in ACT scores between first- and continuing-generation students is statistically significant. ACT scores are statistically significantly different among all three sub-groups of first-generation students (i.e., those with high, medium, and low college GPA) in all three academic years involved in the present study.

Keywords: first-generation; continuing-generation; engineering undergraduates; college GPA; ACT scores; non-parametric statistical analysis

1. Introduction

1.1 Experience and Academic Performance of First-Generation Students

First-generation college students are generally defined as undergraduates whose parents' highest level of education is a high school diploma or less, or whose parents have never enrolled in postsecondary education [1, 2]. Statistics from the U.S. Department of Education have shown that on average, first-generation students account for 43% of college students in the U.S. according to the previous statistics report in 1998 [1] and 24% according to the recent statistics report in 2017 [2]. The percentages vary from 25% to 67% [1] and from 5% to 76% [2] at individual institutions, depending on institution types: 4-year or 2-year, public or private, and for-profit or not-for-profit.

In addition to their significant percentage and number in higher education, first-generation students are different from their continuing-generation peers in many academic and non-academic aspects. For instance, they more likely come from low-income families with racial and ethnic minority backgrounds, are less prepared to enter college, possess lower self-concept or self-efficacy, interact less with instructors, and utilize fewer education resources provided by their institutions [3–6]. Engle and Tinto [7] reported that compared to their continuing-generation peers, low-income first-generation students were nearly four times (26% vs. 7%) as likely to leave higher education after the first year of college study; and six years later, nearly half (43%) of them had left college without earning their degrees.

The vast majority of the literature on first-generation students in all disciplines as a whole has been focusing on the challenges and barriers they have experienced or confronted [1–3, 8–11]. Stebleton and Soria [9] identified several obstacles to academic success of first-generation students, including competing job responsibilities, family responsibilities, weak math and English skills, inadequate study skills, and feeling depressed, stressed, or upset. As part of a three-year longitudinal national study, Terenzini et al. [11] found that compared to their continuing-generation peers, first-generation students were more likely to receive less encouragement from parents, had lower degree aspiration, and had weaker cognitive skills in reading, math, and critical thinking. Terenzini et al. [11] also reported that first-generation students entered college less well-prepared with more non-academic demands on them [11].

Research on first-generation students in science, technology, engineering, and mathematics (STEM) disciplines has been particularly focusing on three topics: (1) understanding and developing first-gen-

* Accepted 20 March 2021.

eration students' sense of belonging in STEM, especially in engineering [12–15]; (2) understanding and improving their college persistence and retention [16–18]; and (3) developing a variety of education interventions to improve their academic performance and success [19–23]. For example, Verdín et al. [12] administrated a survey to 675 first-year female engineering students, including 144 first-generation students and 531 continuing-generation students, at four higher education institutions in the U.S. Through quantitative analysis of survey data, Verdín et al. [12] found that first-generation students' grit-perseverance of effort was associated with their feelings of competence, and that their grit-consistency of interest was related to their initial interest in engineering.

Hartman et al. [16] studied the data drawn from a baseline survey about the climate for diversity and inclusion. The survey was administered to 293 engineering students at a public, minority-serving institution in the U.S., including 105 (36%) first-generation students. Hartman et al. [16] found that compared to their continuing-generation peers, first-generation students were less likely to participate in Advance Placement (AP) and Honors STEM classes in high school, and were less likely to attend extra-curricular activities in college, such as extra-curricular engineering projects, engineering service clubs, student professional societies, and mentoring programs.

1.2 Impact of First-Generation Students' Academic Preparation in High School

Research has shown that first-generation students' academic performance in college is affected by many important factors, such as incoming academic preparation in high school and social-psychological factors [24, 25]. Salehi et al. [24] conducted statistical regression and Structural Equation Modeling analysis on first-generation and minority students in two STEM colleges at a public research university in the U.S. They concluded that incoming academic preparation was the major mediator for students' demographic gaps in exam performance in introductory STEM courses in college.

Higher education institutions in the U.S. traditionally employ one of two standardized tests to assess high school students' academic preparation for college admission: either the Scholastic Assessment Test (SAT) or American College Testing (ACT) [26, 27]. ACT tests, administered by the College Board, include four sections: English, mathematics, reading, and science. Students are scored at a scale of 0–36 for each test section. LeBeau et al. [26] examined the relationship between students' high school characteristics and their completion of a STEM major in college. Through a quasi-experimental design of cross-sectional data, LeBeau et al. [26] found that ACT mathematics score, gender, and high school mathematics GPA were significant factors to predict whether a student would complete a STEM degree in college. Based on a correlation analysis, Kuo and Ghosh [27] found that college admission officers often employed exam scores in high school mathematics and physics as two criteria, among others, to accept high school student applicants into college.

1.3 Innovation and Scientific Contributions of the Present Study

The present study is innovative because it investigates the relationship between first-generation undergraduate engineering students' college graduate point average (GPA) and ACT scores across all four years of undergraduate study. The corresponding terms employed in the U.S. are freshman, sophomore, junior, and senior years. In comparison, relevant existing research [30–33] has been primarily focusing on how first-generation students' academic preparation in high school affect their college GPA in the first year (i.e., freshman year) of undergraduate study only. For instance, Tinnell et al. [30] investigated how ACT scores affected the first-year GPA of engineering undergraduates. Based on a limited sample (n = 161), Coyle and Pillow [33] also examined how ACT scores affected freshman GPA. The present study aims to understand how ACT scores affect college GPA across the entire undergraduate study, so predictive models can be developed in the future to predict student persistence and retention in each year of undergraduate study.

Moreover, the present study involves a significant amount of data collected from three academic years. Each academic year involved freshman, sophomore, junior, and senior students. The total number of student records was 6,683. Each student record included five data points: college GPA, ACT English score, ACT math score, ACT reading score, and ACT science score. Therefore, the present study involves a total of $6{,}683 \times 5 = 33{,}415$ data points. The significant amount of data included in the present study makes statistical analysis meaningful and reliable.

2. Research Method and Data Collection

2.1 Research Questions

The present study has the following three research questions:

1. Are undergraduate engineering students' generational status (first- vs. continuing-generation), college GPA, and ACT scores

statistically significantly correlated across all four years of undergraduate study?
2. Is there a statistically significant difference in college GPA and ACT scores between first- and continuing-generation undergraduate engineering students?
3. Is there a statistically significant difference in ACT scores among three sub-groups of first-generation undergraduate engineering students?

In the present study, college GPA is the cumulative GPA that a student has earned at the end of an academic year in undergraduate study. A student's college GPA changes as he or she proceeds from the first year (i.e., freshman year) to the fourth year (i.e., senior year). A student's ACT scores, including ACT English, math, reading, and science scores, do not change in undergraduate study because the student has already taken ACT tests prior to college admission. Three sub-groups of first-generation students are those with high, medium, and low college GPA, respectively. In the present study, on the standard scale of 4.00, a GPA of 3.67–4.00 (i.e., grades of A and A–) is defined as high GPA; 3.00–3.66 (i.e., grades of B and B+) as medium GPA; and 0.00–2.99 (i.e., grades below B) as low GPA.

2.2 Research Method

Quantitative research method involving statistical analysis was employed to answer the three research questions descried above. Specifically, correlation analysis was performed to answer the first research question. Mann-Whitney U tests were conducted to answer the second research question. Kruskal-Wallis tests were performed to answer the third research question. Both Mann-Whitney U and Kruskal-Wallis tests are statistical methods for non-parametric analysis [34]. Section 3.1 of this paper will show that the data collected in the present study do not have a normal distribution. Therefore, conventional statistical methods for parametric analysis (such as Pearson correlation analysis and t-tests) [34] do not apply in the present study.

2.3 Data Collection

The present study was approved by the Institutional Review Broad at the author's university. The author submitted a request to the university to obtain anonymous academic records of undergraduate students enrolled in the College of Engineering in three recent academic years (AY), referred to as AY I, II, and III in this paper. Each student record included college GPA, ACT English score, ACT math score, ACT reading score, and ACT science score. Students' generational status (i.e., first- vs. continuing-generation) and class levels were also indicated in each student record.

After receiving anonymous student records, missing data were excluded from the present study. For example, some students were transferred from other institutions and had no records of ACT scores. Thus, those incomplete student records were not employed. In the end, a total of 6,683 complete student records was employed in the statistical analysis of the present study.

Table 1 lists the number of first- and continuing-generation undergraduate engineering students involved in the present study. The 6,683 student records included 977 (14.6%) records for first-generation students and 5,706 (85.4%) records for continuing-generation students. The 6,683 student records included 2,418 records in AY I, 2,385 records in AY II, and 1,880 records in AY III. To facilitate the description of results in subsequent Section 3 of this paper, AY I freshmen is referred

Table 1. Number of first-generation (FG) and continuing-generation (CG) undergraduate engineering students involved in the present study

Cases	Students	First-generation (FG)	Continuing-generation (CG)	Sub-total
1	AY I freshmen	53	324	377
2	AY I sophomores	68	512	580
3	AY I juniors	74	412	486
4	AY I seniors	152	823	975
5	AY II freshmen	57	273	330
6	AY II sophomores	67	463	530
7	AY II juniors	58	457	515
8	AY II seniors	162	848	1,010
9	AY III freshmen	58	205	263
10	AY III sophomores	55	370	425
11	AY III juniors	58	318	376
12	AY III seniors	115	701	816
	Sub-total	977	5,706	6,683

to as Case 1, AY I sophomores Case 2, . . . , AY III juniors Case 11, and AY III seniors Case 12. In other words, the present study involves a total of 12 cases.

3. Data Analysis and Results

3.1 Normality Tests

Prior to selecting correct methods for statistical analysis, the collected data were examined to determine if they have a normal distribution. If the data have a normal distribution, conventional methods for parametric analysis, such as Pearson correlation analysis and t-tests, can be employed. Otherwise, non-parametric analysis, such as Spearmen correlation analysis and Mann-Whitney tests, should be performed. Therefore, normality tests were performed on all the data involved in the present study, including a combination of Kolmogorov-Smirnov test, Shapiro-Wilk test, test of homogeneity of variance, histograms, and normal Q-Q plots [34].

The results of normality tests show that the data involved in the present study do not have a normal distribution. For instance, Table 2 shows the results of normality tests of college GPA for first- and

Table 2. Normality test results of college GPA for first-generation (FG) and continuing-generation (CG) undergraduate engineering students

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Students	Statistic	df	Sig.[b]	Statistic	df	Sig.[b]
AY I freshmen						
FG	0.092	53	0.200*	0.945	53	0.016
CG	0.131	324	0.000	0.905	324	0.000
AY I sophomores						
FG	0.127	68	0.009	0.949	68	0.007
CG	0.103	521	0.000	0.924	521	0.000
AY I juniors						
FG	0.078	74	0.200*	0.962	74	0.024
CG	0.078	412	0.000	0.956	412	0.000
AY I seniors						
FG	0.062	152	0.200*	0.980	152	0.025
CG	0.060	823	0.000	0.970	823	0.000
AY II freshmen						
FG	0.127	57	0.023	0.919	57	0.001
CG	0.120	273	0.000	0.899	273	0.000
AY II sophomores						
FG	0.114	67	0.029	0.931	67	0.001
CG	0.115	463	0.000	0.919	463	0.000
AY II juniors						
FG	0.134	58	0.012	0.901	58	0.000
CG	0.090	457	0.000	0.947	457	0.000
AY II seniors						
FG	0.070	162	0.051	0.972	162	0.002
CG	0.071	848	0.000	0.961	848	0.000
AY III freshmen						
FG	0.128	58	0.019	0.924	58	0.001
CG	0.127	205	0.000	0.911	205	0.000
AY III sophomores						
FG	0.157	55	0.002	0.897	55	0.000
CG	0.139	370	0.000	0.895	370	0.000
AY III juniors						
FG	0.091	58	0.200*	0.934	58	0.004
CG	0.102	318	0.000	0.941	318	0.000
AY III seniors						
FG	0.064	115	0.200*	0.973	115	0.019
CG	0.074	701	0.000	0.958	701	0.000

* This is a lower bound of the true significance.
[a] Lilliefors significance correction.
[b] The significance level (p-value) less than 0.05 indicates a non-normal distribution of data.

continuing-generation undergraduate engineering students, based on both Kolmogorov-Smirnov and Shapiro-Wilk tests. In general, Shapiro-Wilk tests are more reliable than Kolmogorov-Smirnov tests to determine if the distribution of data is normal or non-normal. As can be seen from the last column in Table 2, the significance level (p-value) for all 12 cases is less than 0.05, indicating a non-normal distribution of data. Thus, statistical methods for non-parametric analysis were subsequently employed in the present study.

3.2 Descriptive Tests

Table 2 shows the results of non-parametric descriptive analysis of college GPA for first- and continuing-generation undergraduate engineering students. Although non-parametric descriptive analysis typically involves median, interquartile, skewness, and kurtosis, among others, Table 2 also includes the values of mean and standard deviation, two primary parameters involved in parametric descriptive analysis. Mean and standard deviation have been widely employed in the engineering education research community; thus including these two common parameters facilitate the dialog between the author and readers of this paper.

As can be seen in Table 3, there exists only a slight

Table 3. Descriptive analysis of college GPA for first-generation (FG) and continuing-generation (CG) undergraduate engineering students

Students	Mean	Median	SD	Min.	Max.	IQR	Skewness	Kurtosis
AY I freshmen								
FG	2.89	3.04	0.81	0.62	3.97	1.31	–0.63	–0.26
CG	2.91	3.17	0.89	0.33	4.00	1.16	–0.98	0.20
AY I sophomores								
FG	3.22	3.35	0.54	1.62	4.00	0.76	–0.75	0.14
CG	3.23	3.36	0.61	0.49	4.00	0.86	–1.02	1.25
AY I juniors								
FG	3.22	3.25	0.53	1.68	4.00	0.76	–0.58	–0.07
CG	3.31	3.32	0.48	1.31	4.00	0.76	–0.55	0.16
AY I seniors								
FG	3.27	3.25	0.41	2.31	4.00	0.63	–0.12	–0.76
CG	3.38	3.41	0.39	2.07	4.00	0.60	–0.42	–0.39
AY II freshmen								
FG	2.79	3.00	1.00	0.38	4.00	1.65	–0.53	–0.87
CG	2.94	3.18	0.89	0.23	4.00	1.17	–1.08	0.60
AY II sophomores								
FG	3.24	3.33	0.56	1.67	4.00	0.79	–0.86	0.17
CG	3.22	3.34	0.65	0.43	4.00	0.89	–1.05	1.22
AY II juniors								
FG	3.12	3.23	0.63	0.97	4.00	0.66	–1.29	1.87
CG	3.32	3.38	0.51	1.14	4.00	0.77	–0.71	0.30
AY II seniors								
FG	3.31	3.30	0.43	2.10	4.00	0.66	–0.35	–0.52
CG	3.39	3.43	0.41	1.83	4.00	0.63	–0.55	–0.02
AY III freshmen								
FG	2.72	3.00	1.00	0.48	4.00	1.58	–0.64	–0.66
CG	2.95	3.19	0.92	0.21	4.00	1.34	–0.87	0.03
AY III sophomores								
FG	3.21	3.38	0.72	1.06	4.00	1.08	–1.01	0.40
CG	3.33	3.52	0.62	0.66	4.00	0.90	–1.14	1.31
AY III juniors								
FG	3.30	3.33	0.51	1.44	4.00	0.78	–1.00	1.91
CG	3.39	3.44	0.48	1.78	4.00	0.77	–0.69	0.04
AY III seniors								
FG	3.37	3.40	0.37	2.13	4.00	0.53	–0.53	0.08
CG	3.43	3.47	0.39	1.93	4.00	0.60	–0.60	0.07

SD: standard deviation; IQR: interquartile range.

Table 4. Spearmen's correlation coefficients between students' generational status and their college GPA and ACT scores

Students	College GPA	ACT English	ACT math	ACT reading	ACT science
AY I freshmen	0.028	0.223**	0.182**	0.224**	0.174**
P-values	0.589	0.000	0.000	0.000	0.001
N	377	377	377	377	377
AY I sophomores	0.023	0.142**	0.122**	0.090*	0.123**
P-values	0.584	0.001	0.003	0.030	0.003
N	589	589	589	589	589
AY I juniors	0.049	0.093*	0.085	0.082	0.065
P-values	0.280	0.040	0.062	0.070	0.153
N	486	486	486	486	486
AY I seniors	0.102**	0.083**	0.079*	0.096**	0.063*
P-values	0.001	0.010	0.013	0.003	0.049
N	975	975	975	975	975
AY II freshmen	0.040	0.195**	0.218**	0.184**	0.168**
P-values	0.471	0.000	0.000	0.001	0.002
N	330	330	330	330	330
AY II sophomores	0.008	0.079	0.116**	0.105*	0.070
P-values	0.850	0.068	0.008	0.015	0.108
N	530	530	530	530	530
AY II juniors	0.098*	0.178**	0.149**	0.127**	0.172**
P-values	0.026	0.000	0.001	0.004	0.000
N	515	515	515	515	515
AY II seniors	0.070*	0.101**	0.090**	0.103**	0.075*
P-values	0.026	0.001	0.004	0.001	0.017
N	1,010	1,010	1,010	1,010	1,010
AY III freshmen	0.104	0.186**	0.161**	0.225**	0.173**
P-values	0.092	0.002	0.009	0.000	0.005
N	263	263	263	263	263
AY III sophomores	0.047	0.022	0.060	0.037	0.037
P-values	0.332	0.644	0.218	0.443	0.443
N	425	425	425	425	425
AY III juniors	0.066	0.111*	0.147**	0.163**	0.140**
P-values	0.199	0.031	0.004	0.001	0.007
N	376	376	376	376	376
AY III seniors	0.064	0.109**	0.081*	0.105**	0.109**
P-values	0.068	0.002	0.020	0.003	0.002
N	816	816	816	816	816

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

difference in the mean and median values of college GPA between first- and continuing-generation students in each of the 12 cases. For example, in the first case (AY I freshmen), the mean values are 2.89 and 2.91, and the median values are 3.04 and 3.17 for first- and continuing-generation students, respectively. In the last 12th case (AY III seniors), the mean values are 3.37 and 3.43, and the median values are 3.40 and 3.47 for first- and continuing-generation students, respectively. The difference in standard deviation and interquartile of college GPA between first- and continuing-generation students is not significant either in all 12 cases. Note that these comparisons are made within the same case, not across different cases. For instance, the collage GPA of first-generation students in Case 1 are compared to that of continuing-generation students in the same Case 1.

3.3 Correlation Analysis

Spearmen's correlation analysis was performed to determine if students' generational status (first- vs. continuing-generation), college GPA, and ACT scores are correlated across all four years of undergraduate study. Table 4 shows spearmen's correlation coefficients between students' generational status and their college GPA and ACT scores. Table 5 shows Spearmen's correlation coefficients between students' college GPA and their generational status and ACT scores.

Refer to Table 4. The p-values in the second column show that students' generational status and college GPA are statistically significantly correlated only in 3 out of 12 cases: AY I seniors, AY II juniors, and AY II seniors. The p-values in the 3rd-6th columns show that students' generational status and ACT scores are statistically significantly correlated in the majority of 12 cases: 10 cases for ACT English, 10 cases for ACT math, 10 cases for ACT reading, and 9 cases for ACT science. From Table 4, it can be concluded that in general, students' generational status is not statistically significantly correlated with college GPA, and is statistically significantly correlated with ACT scores. The words of "in general" are employed to indicate that exceptions exist.

Refer to Table 5. The p-values in the 3rd–6th columns show that college GPA and ACT scores are statistically significantly correlated in nearly all cases: 12 cases for ACT English, 12 cases for ACT math, 11 cases for ACT reading, and 12 cases for ACT science. The only exception is the case of AY III freshmen for ACT reading, where the p-value is 0.054, only slightly greater than 0.05. From Table 5, it can be concluded, with strong evidence, that college GPA is statistically significantly correlated with ACT scores.

Table 5. Spearmen's correlation coefficients between students' college GPA and their generational status and ACT scores

Students	Generational status	ACT English	ACT math	ACT reading	ACT science
AY I freshmen	0.028	0.265**	0.331**	0.203**	0.275**
P-values	0.589	0.000	0.000	0.000	0.000
N	377	377	377	377	377
AY I sophomores	0.023	0.356**	0.346**	0.256**	0.302**
P-values	0.584	0.000	0.000	0.000	0.000
N	589	589	589	589	589
AY I juniors	0.049	0.390**	0.398**	0.309**	0.341**
P-values	0.280	0.000	0.000	0.000	0.000
N	486	486	486	486	486
AY I seniors	0.102**	0.435**	0.411**	0.432**	0.323**
P-values	0.001	0.000	0.000	0.000	0.000
N	975	975	975	975	975
AY II freshmen	0.040	0.310**	0.307**	0.214**	0.295**
P-values	0.471	0.000	0.000	0.000	0.000
N	330	330	330	330	330
AY II sophomores	0.008	0.380**	0.367**	0.316**	0.325**
P-values	0.850	0.000	0.000	0.000	0.000
N	530	530	530	530	530
AY II juniors	0.098*	0.385**	0.426**	0.284**	0.341**
P-values	0.026	0.000	0.000	0.000	0.000
N	515	515	515	515	515
AY II seniors	0.070*	0.424**	0.421**	0.353**	0.398**
P-values	0.026	0.000	0.000	0.000	0.000
N	1,010	1,010	1,010	1,010	1,010
AY III freshmen	0.104	0.213**	0.217**	0.119	0.194**
P-values	0.092	0.001	0.000	0.054	0.002
N	263	263	263	263	263
AY III sophomores	0.047	0.383**	0.409**	0.314**	0.327**
P-values	0.332	0.000	0.000	0.000	0.000
N	425	425	425	425	425
AY III juniors	0.066	0.362**	0.383**	0.325**	0.368**
P-values	0.199	0.000	0.000	0.000	0.000
N	376	376	376	376	376
AY III seniors	0.064	0.416**	0.450**	0.344**	0.394**
P-values	0.068	0.000	0.000	0.000	0.000
N	816	816	816	816	816

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

3.4 *Mann-Whitney U tests*

Mann-Whitney U tests were conducted to determine if there is a statistically significant difference in college GPA and ACT scores between first- and continuing-generation students. Tables 6–8 show the results of Mann-Whitney U tests for AY I, II, and III, respectively. In Tables 6–8, the asymptotic significance level (p-value) less than 0.05 indicates the significant difference between first- and continuing-generation students.

For AY I, Table 6 shows that the difference in college GPA between first- and continuing-generation students is not statistically significant for freshmen, sophomores, and juniors, but is statistically significant for seniors. The difference in ACT scores between first- and continuing-generation students is statistically significant for all students, expect ACT science scores for AY I juniors.

For AY II, Table 7 illustrates that the difference in college GPA between first- and continuing-generation students is not statistically significant for freshmen and sophomores, but is statistically significant for juniors and seniors. The difference in ACT scores between first- and continuing-generation students is statistically significant for all students, except ACT science scores for AY II sophomores.

For AY III, Table 8 shows that the difference in college GPA between first- and continuing-generation students is not statistically significant for all students. The difference in ACT scores between first- and continuing-generation students is statistically significant for freshmen, sophomores, and seniors, but is not statistically significant for juniors.

It can be concluded from Tables 6–8 that in general, the difference in college GPA between first- and continuing-generation students is not statistically significant, and the difference in ACT scores between first- and continuing-generation students is statistically significant. Again, the words of "in general" are employed to indicate that exceptions exist. These conclusions hold as long as students in comparisons are at the same class level (i.e., freshmen, sophomore, juniors, or seniors) and in the same academic year.

3.5 *Kruskal-Wallis tests*

Kruskal-Wallis tests were performed to determine if there is a statistically significant difference in ACT scores among three sub-groups of first-generation students. The three sub-groups included those with high (3.67–4.00), medium (3.00–3.66), and low (0.00–2.99) college GPA. No existing literature

Table 6. Mann-Whitney test results for first-generation (FG) and continuing-generation (CG) undergraduate engineering students in AY I

Students	**Mann-Whitney U**	**z**	**Asymp. sig.**[a]
AY I freshmen			
College GPA	8,187.5	–0.542	0.588
ACT English	5,416.0	–4.319	0.000
ACT math	6,001.0	–3.525	0.000
ACT reading	5,393.0	–4.349	0.000
ACT science	6,115.0	–3.370	0.001
AY I sophomores			
College GPA	16,990.5	–0.548	0.584
ACT English	13,163.5	–3.454	0.001
ACT math	13,830.5	–2.952	0.003
ACT reading	14,851.0	–2.173	0.030
ACT science	13,796.0	–2.976	0.003
AY I juniors			
College GPA	14,040.5	–1.082	0.279
ACT English	12,962.5	–2.055	0.040
ACT math	13,177.5	–1.864	0.062
ACT reading	13,235.0	–1.809	0.070
ACT science	13,656.5	–1.430	0.153
AY I seniors			
College GPA	52,358.0	–3.195	0.001
ACT English	54,665.0	–2.475	0.013
ACT math	52,991.5	–3.005	0.003
ACT reading	56,283.5	–1.967	0.049
ACT science	54,926.0	–2.395	0.017

[a] The asymptotic significance level (p-value) less than 0.05 indicates the significant difference between FG and CG students.

Table 7. Mann-Whitney test results for first-generation (FG) and continuing-generation (CG) undergraduate engineering students in AY II

Students	Mann-Whitney U	z	Asymp. sig.[a]
AY II freshmen			
College GPA	7,307.5	–0.722	0.470
ACT English	5,473.5	–3.528	0.000
ACT math	5,198.0	–3.955	0.000
ACT reading	5,602.0	–3.331	0.001
ACT science	5,787.5	–3.051	0.002
AY II sophomores			
College GPA	15,288.5	–0.190	0.850
ACT English	13,377.5	–1.823	0.068
ACT math	12,406.0	–2.659	0.008
ACT reading	12,681.5	–2.419	0.016
ACT science	13,630.5	–1.608	0.108
AY II juniors			
College GPA	10,875.0	–2.228	0.026
ACT English	8,942.0	–4.045	0.000
ACT math	9,651.5	–3.384	0.001
ACT reading	10,189.0	–2.875	0.004
ACT science	9,109.0	–3.890	0.000
AY II seniors			
College GPA	61,139.0	–2.219	0.026
ACT English	57,754.0	–3.219	0.001
ACT math	59,025.0	–2.849	0.004
ACT reading	57,614.5	–3.261	0.001
ACT science	60,570.0	–2.392	0.017

[a] The asymptotic significance level (p-value) less than 0.05 indicates the significant difference between FG and CG students.

Table 8. Mann-Whitney test results for first-generation (FG) and continuing-generation (CG) undergraduate engineering students in AY III

Students	Mann-Whitney U	z	Asymp. sig.[a]
AY III freshmen			
College GPA	5,083.5	–1.685	0.092
ACT English	4,408.0	–3.011	0.003
ACT math	4,616.0	–2.606	0.009
ACT reading	4,088.5	–3.636	0.000
ACT science	4,519.0	–2.797	0.005
AY III sophomores			
College GPA	9,349.5	–0.972	0.331
ACT English	9,782.0	–0.463	0.643
ACT math	9,130.0	–1.233	0.217
ACT reading	9,522.5	–0.769	0.442
ACT science	9,523.5	–0.768	0.442
AY III juniors			
College GPA	8,243.0	–1.286	0.198
ACT English	7,581.5	–2.159	0.031
ACT math	7,058.5	–2.851	0.004
ACT reading	6,817.5	–3.164	0.002
ACT science	7,163.5	–2.710	0.007
AY III seniors			
College GPA	36,038.5	–1.822	0.068
ACT English	33,060.5	–3.098	0.002
ACT math	34,876.5	–2.326	0.020
ACT reading	33,282.5	–3.004	0.003
ACT science	33,013.5	–3.120	0.002

[a] The asymptotic significance level (p-value) less than 0.05 indicates the significant difference between FG and CG students.

Table 9. Kruskal-Wallis test results for first-generation undergraduate engineering students in AY I

Comparisons	N	Mean rank	Kruskal-Wallis H	Asymp. sig.[a]
College GPA				
High college GPA group	73	311.00	294.88	0.000
Medium college GPA group	165	192.00		
Low college GPA group	109	55.00		
ACT English				
High college GPA group	73	229.21	38.06	0.000
Medium college GPA group	165	174.80		
Low college GPA group	109	135.81		
ACT math				
High college GPA group	73	231.30	38.54	0.000
Medium college GPA group	165	172.82		
Low college GPA group	109	137.42		
ACT reading				
High college GPA group	73	214.91	25.68	0.000
Medium college GPA group	165	178.85		
Low college GPA group	109	139.27		
ACT science				
High college GPA group	73	235.23	40.48	0.000
Medium college GPA group	165	169.59		
Low college GPA group	109	139.67		

[a] The asymptotic significance level (p-value) less than 0.05 indicates the significant difference between groups.

has been found to divide first-generation students into sub-groups based on their college GPA.

Tables 9–11 show the results of Kruskal-Wallis tests for AY I, II, and III, respectively. In Tables 9–11, the asymptotic significance level (p-value) less than 0.05 also indicates the significant difference between first- and continuing-generation students. As can be seen from the last column in Tables 9–11, ACT scores are statistically significantly different among all three sub-groups of first-generation students in all three academic years. The asymptotic significance level is 0.000, less than 0.01.

Table 10. Kruskal-Wallis test results for first-generation undergraduate engineering students in AY II

Comparisons	N	Mean rank	Kruskal-Wallis H	Asymp. sig.[a]
College GPA				
High college GPA group	84	302.50	295.87	0.000
Medium college GPA group	158	181.50		
Low college GPA group	102	51.50		
ACT English				
High college GPA group	84	223.92	42.48	0.000
Medium college GPA group	158	173.48		
Low college GPA group	102	128.63		
ACT math				
High college GPA group	84	224.67	43.04	0.000
Medium college GPA group	158	172.95		
Low college GPA group	102	128.84		
ACT reading				
High college GPA group	84	211.49	28.15	0.000
Medium college GPA group	158	176.32		
Low college GPA group	102	134.48		
ACT science				
High college GPA group	84	227.68	42.39	0.000
Medium college GPA group	158	168.61		
Low college GPA group	102	133.08		

[a] The asymptotic significance level (p-value) less than 0.05 indicates the significant difference between groups.

Table 11. Kruskal-Wallis test results for first-generation undergraduate engineering students in AY III

Comparisons	N	Mean rank	Kruskal-Wallis H	Asymp. sig.[a]
College GPA				
High college GPA group	74	249.50	246.63	0.000
Medium college GPA group	130	147.50		
Low college GPA group	82	41.50		
ACT English				
High college GPA group	74	181.55	25.36	0.000
Medium college GPA group	130	139.39		
Low college GPA group	82	115.68		
ACT math				
High college GPA group	74	177.24	20.57	0.000
Medium college GPA group	130	140.57		
Low college GPA group	82	117.70		
ACT reading				
High college GPA group	74	178.27	20.11	0.000
Medium college GPA group	130	138.35		
Low college GPA group	82	120.28		
ACT science				
High college GPA group	74	180.43	20.17	0.000
Medium college GPA group	130	132.32		
Low college GPA group	82	127.89		

[a] The asymptotic significance level (p-value) less than 0.05 indicates the significant difference between groups.

4. Discussions

The present study involved academic records of engineering undergraduates in three academic years. In other words, the object of the present study was engineering students, rather than students in other non-engineering majors. Research studies involving different student majors might lead to conflicting research findings about academic performance of first-generation college students.

For example, taking all student majors as a whole, Ives and Castillo-Montoya [3] and Eveland [19] reported that the college GPA of first-generation students was generally lower than that of their continuing-generation peers. First-generation students were often associated with lower retention, or higher dropout rates [16–18]. On the other hand, based on the data collected from 322 college students in psychology majors including 26.3% first-generation and 73.7% continuing-generation students, Aspelmeier et al. [5] found that the difference in college GPA between first- and continuing-generation students was quite small. Involving 6,683 academic records of engineering undergraduates in three academic years, the present study concludes that in general, there exists no statistically significant difference in college GPA between first- and continuing-generation students. This conclusion supports the research findings made by Aspelmeier et al. [5].

Moreover, the results of the present study show that ACT scores between first- and continuing-generation students is statistically significant and that ACT scores are statistically significantly correlated with college GPA. These research findings imply that the difference in academic performance between first- and continuing-generation college students do not start in post-secondary education, but start earlier in elementary and secondary education. To improve educational attainment of first-generation college students, efforts should be made as early as possible in elementary and secondary education. This does not mean no efforts should be made in post-secondary education. How to improve teaching and learning at all education levels (elementary, secondary, and post-secondary) is a complex topic due to effects of numerous factors [3, 8] and is beyond the scope of the present study.

It should also be noted that the present study has two primary limitations. First, all data were collected from a single institution, the author's university, which is classified as a 4-year public research institution in the U.S. Because student backgrounds and experiences vary from institution to institution [3, 10, 11], the research findings described in Section 3 might not be applicable to other types of institutions, such as 2-year, private, or teaching institutions. In their extensive literature review on first-generation college students, Ives and Castillo-Montoya [3] have shown that the type of institution plays an important role in affecting student outcomes.

Second, the present study focuses on statistical analysis of first- and continuing-generation students' college GPA and ACT scores. Students' high school GPA was not included in the present study. Relevant research [8] has shown that in addition to ACT scores, students' high school GPA correlates positively with their college GPA. This correlation will be examined in the author's future work.

5. Conclusions

Prior research on first-generation college students in STEM disciplines has primarily focused on understanding and improving their sense of belonging, persistence, retention, as well as their academic performance and success. The present study adds to the knowledge base through a deep investigation of the relationship between first-generation undergraduate engineering students' college GPA and ACT scores across the entire undergraduate study.

In the present study, non-parametric statistical analysis has been performed based on 6,683 student records in recent three academic years, involving 33,415 data points. The 6,683 student records included 977 (14.6%) records for first-generation students and 5,706 (85.4%) records for continuing-generation students. The following paragraphs summarize the major research findings made from the present study:

1. There exists no significant difference in the mean, median, standard deviation, and interquartile of college GPA between first- and continuing-generation students.
2. In general, students' generational status is not statistically significantly correlated with college GPA, but is statistically significantly correlated with ACT scores.
3. Strong evidence suggests that college GPA is statistically significantly correlated with ACT scores.
4. In general, the difference in college GPA between first- and continuing-generation students is not statistically significant, while the difference in ACT scores between first- and continuing-generation students is statistically significant.
5. ACT scores are statistically significantly different among all three sub-groups of first-generation students (i.e., those with high, medium, and low college GPA) in all three academic years involved in the present study.

References

1. U.S. Department of Education, *First-Generation Students: Undergraduates Whose Parents Never Enrolled in Postsecondary Education*, Statistical Analysis Report (NCES 98-082) of the National Center for Education Statistics by A. M. Nunez, S. C. Alamin, and C. D. Carroll, Washington D.C., 1998.
2. U.S. Department of Education, *First-Generation and Continuing-Generation College Students: A Comparison of High School and Postsecondary Experiences*, Statistical Analysis Report (NCES 2018–19) of the National Center for Education Statistics by J. Redford, K. M. Hoyer, and J. Ralph, Washington D.C., 2017.
3. J. Ives and M. Castillo-Montoya, First-generation college students as academic learners: A systematic review, *Review of Educational Research*, **90**(2), pp. 139–178, 2020.
4. G. M. Bettencourt, C. A. Manly, E. Kimball and R. S. Wells, STEM degree completion and first-generation college students: A cumulative disadvantage approach to the outcomes gap, *Review of Higher Education*, **43**(3), pp. 753–779, 2020.
5. J. E. Aspelmeier, M. M. Love, L. A. McGill, A. N. Elliott and T. W. Pierce, Self-esteem, locus of control, college adjustment, and GPA among first- and continuing-generation students: A moderator model of generational status, *Research in Higher Education*, **53**(7), pp. 755–781, 2012.
6. J. Engle, Postsecondary access and success for first-generation college students, *American Academic*, **3**(1), pp. 25–48, 2007.
7. J. Engle and V. Tinto, *Moving Beyond Access: College for Low-Income, First-Generation Students*, The Pell Institute, Washington D.C., 2008.
8. T. Spiegler and A. Bednarek, First-generation students: What we ask, what we know and what it means: An international review of the state of research, *International Studies in Sociology of Education*, **23**(4), pp. 318–337, 2013.
9. M. J. Stebleton and K. M. Soria, Breaking down barriers: Academic obstacles of first-generation students at research universities, *Learning Assistance Review*, **17**(2), pp. 7–20, 2012.
10. E. T. Pascarella, C. T. Pierson, G. C. Wolniak and P. T. Terenzini, First-generation college students: Additional evidence on college experiences and outcomes, *The Journal of Higher Education*, **75**(3), pp. 249–284, 2004.
11. P. T. Terenzini, L. Springer, P. M. Yaeger, E. T. Pascarella and A. Nora, First-generation college students: Characteristics, experiences, and cognitive development, *Research in Higher Education*, **37**(1), pp. 1–22, 1996.
12. D. Verdín, A. Godwin, A. Kirn, L. Benson and G. Potvin, Engineering role identity fosters grit differently for women first- and continuing-generation college students, *International Journal of Engineering Education*, **35**(4), pp. 1037–1051, 2019.
13. H. Boone and A, Kirn, First generation students' engineering belongingness, *Proceedings of the 2017 ASEE Annual Conference & Exposition*, Columbus, OH, 2017.
14. J. M. Smith and J. C. Lucena, Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering, *Engineering Studies*, **8**(1), pp. 1–26, 2016.
15. J. Blue, B. Johnson, A. Summerville and B. P. Kirkmeyer, Beliefs and behaviors of first-generation and low-income students in early engineering courses, *Proceedings of the 2018 ASEE Annual Conference & Exposition*, Salt Lake City, UT, 2018.

16. H. Hartman, R. A. Farrell, B. Sukumaran, S. Farrell, T. R. Forin, S. Lezotte, K. Jahan, S. K. Bauer and D. Zeppilli, First-generation college students and othering in undergraduate engineering, *Proceedings of the 2019 ASEE Annual Conference & Exposition*, Tampa, FL, 2019.
17. J. Paz, M. Cousins, C. D. Wilson and M. K. Markey, Retention of first-year undergraduate engineering students: Role of psychosocial interventions targeting first-generation college students, *Proceedings of the 2015 ASEE Annual Conference & Exposition*, Seattle, WA, 2015.
18. H. S. Lee, L. Y. Flores, R. L. Navarro and M. Kanagui-Muñozd, A longitudinal test of social cognitive career theory's academic persistence model among Latino/a and white men and women engineering students, *Journal of Vocational Behavior*, **88**(June), pp. 95–103, 2015.
19. T. J. Eveland, Supporting first-generation college students: analyzing academic and social support's effects on academic performance, *Journal of Further and Higher Education*, **44**(8), pp. 1039–1051, 2020.
20. J. Liou-Mark, R. Blake and R. Li, Exploring the impacts of a geoscience research experience on first-generation college students in engineering-related majors, *Proceedings of the 2020 ASEE Annual Conference & Exposition*, virtual conference, 2020.
21. B. P. Nepal, M. Johnson, T. J. Jacobs and M. Weichold, First generation engineering student mentoring program: A case study of a large engineering school in the U.S., *Proceedings of the 2018 ASEE Annual Conference & Exposition*, Salt Lake City, UT, 2018.
22. L. C. Reimer, K. Schenke, T. Nguyen, D. K. O'Dowd, T. Domina and M. Warschauer, Evaluating promising practices in undergraduate STEM lecture courses, *RSF: The Russell Sage Foundation Journal of the Social Sciences*, **2**(1), pp. 212–233, 2016.
23. S. L. Dika and M. M. D'Amico, Early experiences and integration in the persistence of first-generation college students in STEM and non-STEM majors, *Journal of Research in Science Teaching*, **53**(3), pp. 368–283, 2016.
24. S. Salehi1, S. Cotner and C. J. Ballen, Variation in incoming academic preparation: Consequences for minority and first-generation students, *Frontiers in Education*, **5**, article no. 552364, pp. 1–14, 2020.
25. A. L. Kaleita, G. R. Forbes, E. Ralston, J. I. Compton, D. Wohlgemuth and D. R. Raman, Pre-enrollment identification of at-risk students in a large engineering college, *International Journal of Engineering Education*, **32**(4), pp. 1647–1659, 2016.
26. B. LeBeau, M. Harwell, D. Monson, D. Dupuis, A. Medhanie and T. R. Post, Student and high-school characteristics related to completing a science, technology, engineering or mathematics (STEM) major in college, *Research in Science & Technological Education*, **30**(1), pp. 17–28, 2012.
27. R. Kuo and S. Ghosh, A correlation-based study of the admissions criteria in a B.Sc. engineering program, *International Journal of Engineering Education*, **14**(2), pp. 95–104, 1998.
28. J. Wao, K. B. Bivins, R. Ries and S. Schattner, SAT and ACT scores as predictors of undergraduate GPA scores of construction science and management students, *Proceedings of the 53rd ASC Annual International Conference*, Seattle, WA, 2017.
29. P. A. Westrick, H. Le, S. B. Robbins, J. M. R. Radunzel and F. L. Schmidt, College performance and retention: A meta-analysis of the predictive validities of ACT® scores, high school grades, and SES, *Educational Assessment*, **20**(1), pp. 23–45, 2015.
30. T. L. Tinnell, N. Honken and P. A. Ealston, ACT preparation and the percent of variability in first year engineering student GPA explained by ACT scores, *Proceedings of the 2020 ASEE Annual Conference & Exposition*, virtual conference, 2020.
31. N. Schmitt, J. Keeney, F. L. Oswald, T. J. Pleskac, A. Q. Billington, R. Sinha and M. Zorzie, Prediction of 4-year college student performance using cognitive and noncognitive predictors and the impact on demographic status of admitted students, *Journal of Applied Psychology*, **94**(6), pp. 1479–1497, 2009.
32. C. P. Veenstra, E. L. Dey and G. D. Herrin, Is modeling of freshman engineering success different from modeling of non-engineering success? *Journal of Engineering Education*, **97**(4), pp. 467–479, 2008.
33. T. R. Coyle and D. R. Pillow, SAT and ACT predict college GPA after removing g, *Intelligence*, **36**(6), pp. 719–729, 2008.
34. R. Hogg, *Modern Statistics, Methods and Applications*, American Mathematical Society, San Antonio, TX, 1980.

Ning Fang is Professor and Department Head of the Department of Engineering Education at Utah State University, U.S.A. He has taught a variety of courses at both graduate and undergraduate levels, such as Engineering Dynamics, metal machining, and design for manufacturing. His research in engineering education are in broad areas of engineering learning & problem solving, technology enhanced learning, and K-12 STEM education. His research in engineering focuses on the modeling and optimization of metal machining processes. He earned his PhD, MS, and BS degrees in mechanical engineering. He is a member of the American Society of Mechanical Engineers (ASME) and the American Society for Engineering Education (ASEE).