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Effects of Generation Status and Gender on the Academic Performance of Engineering Undergraduates (Research)

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ABSTRACT

The persistent 0.1 to 0.3-point grade point average (GPA) gap between first-generation college students (FGCSs) and continuing-generation college students (CGCSs) is usually established in the first year and persists through students' undergraduate studies. This gap poses a critical challenge to educational equity and to STEM retention and graduation. Existing literature relies on short-term data and traditional four- to six-year graduation benchmarks, which limit sample size and constrain the generalizability of the findings. Moreover, few studies examine how generational status and gender interact, failing to reveal the effects of overlapping multiple underrepresented identities on student GPA in STEM environments. The purpose of this quantitative study is to fill these research gaps by analyzing term and overall GPAs for FGCSs and CGCSs in engineering at a public research university in the Mountain West region of the United States. The research questions of the present study are: (1) What are the yearly trends in term and overall GPAs, and are the differences statistically significant? (2) How do generational status and gender interact to influence term and overall GPAs, and are patterns consistent across years?

The sample in the present study comprised 8,835 undergraduate students enrolled in or who had graduated from the College of Engineering at Utah State University (USU) over 11 years, from 2014 to 2024. A cross-sectional analysis of non-normally distributed data ($p < 0.05$) uses the Mann-Whitney test for the "What" question and two-way ANOVAs for the "How" question in the present study. The results revealed that the GPA gaps narrowed over time, from 0.18 points in 2014 to 0.09 points in 2024. The Mann-Whitney test indicated a statistically significant difference in overall GPA, with CGCSs outperforming FGCSs in all years and in 10 of 11 years for term GPA ($p < 0.05$). Two-way ANOVAs also confirmed a consistent generational status effect yet showed an inconsistent gender effect ($p < 0.05$ in five years for overall GPA and four years for term GPA), with only a small proportion of the variance in GPAs (eta-square < 0.01). However, no significant interaction between these two identities was found on any metric across all years ($p > 0.05$). These results are consistent with the presence and expansion of first-generation–focused supports, including the Aggie UP program, the Aggie First Scholars program, and TRIO Student Support Services at USU, over the 11-year study period. This analysis, however, focuses on examining aggregate GPA trends rather than the causal efficacy of specific interventions, providing a baseline for future evaluative research.

Keywords: first-generation engineering students, GPAs, gender effects, longitudinal analysis

INTRODUCTION

The First-Generation Achievement Gap and Beyond the Traditional Academic Window

According to the U.S. Department of Education's official definition for federal student aid programs, a first-generation college student (FGCS) is an individual whose parents (or, if regularly residing with and supported by only one parent, whose sole parent) did not complete a baccalaureate degree [1]. Consistent with this definition, research across postsecondary education contexts found that FGCSs achieved lower grade point averages (GPAs) than continuing-generation college students (CGCSs) [2, 3]. For instance, observations at 4-year institutions have revealed that FGCSs had an average GPA of 2.6, compared with 2.9 for CGCSs, with this 0.3-point gap emerging in the first year and persisting throughout undergraduate studies [2]. Similarly, longitudinal tracking at a Midwestern university found that GPA gaps ranged from 0.13 to 0.19 GPA points across 2011–2014 cohorts, with the most significant disparities in Year 1 as well [4].

This academic underperformance among FGCSs has been documented in STEM education, particularly in introductory courses. In one introductory biology course, for example, CGCSs earned significantly higher final course grades (2.63) than FGCSs (1.89), showing an average difference of 0.74 GPA points [5]. This pattern holds in introductory physics courses, with differences of approximately 0.3 GPA points [6]. Extending these trends to engineering programs, a preliminary analysis of engineering technology students found that FGCSs earned a lower term GPA (2.85) than their peers (2.91) [7]. Moreover, in core engineering classes, FGCSs were found to have a GPA of 0.15 to 0.2 lower [8]. In terms of major fields, FGCSs in mathematics and science majors exhibited average GPAs of 2.6 and 2.5, respectively, compared to GPAs of 3.1 in mathematics and 2.9 in science among CGCSs [2]. In engineering majors, these gaps contribute to reduced persistence, with FGCSs showing retention rates seven to eleven percentage points lower in the first and second years [9]. In summary, data from multiple studies indicate lower GPAs for FGCSs, typically by 0.1-0.3 points, demonstrating the systemic nature of generational disparities in academic success.

However, the literature on academic performance is limited by its dependence on significantly outdated data, which obscures the specific experiences of today's FGCSs. As highlighted by Weisen et al. [4], foundational studies rarely reviewed data beyond the early 2000s. For example, Núñez and Cuccaro-Alamin (1998) and Ishitani (2006) analyzed data up through 1994; Chen [2] through 2000; and Engle and Tinto [10] through 2004. Weisen et al. [4] addressed this by examining data from 2011-2014 cohorts through 2018, thereby extending the analysis into the mid-2010s. Furthermore, FGCSs had a long path to earn a bachelor's degree, with more than twice the likelihood (16 percent to 7 percent) of remaining enrolled after six years compared with their most advantaged peers [10]. For example, in four-year public institutions, only 34 percent of FGCSs compared with 66 percent of CGCSs, and the overall gap was 11 percent, compared with 55 percent [10].

This delayed completion stems from attending part-time and working full-time while enrolled, which is identified as a critical risk factor of FGCSs. Among them, 52 percent enrolled part-time, and 37 percent worked full-time [2, 10, 11]. FGCSs are also more likely to repeat or withdraw from courses, with a 12 percent repeat-or-withdrawal rate compared with 7 percent among their peers [2, 4]. In engineering technology, FGCSs earned significantly more unsatisfactory grades ("D," "F," "W," "WE," "N," or "I"), accounting for 22% of all grades, compared with 18% for

CGCSs [7]. As a result, FGCSs earned fewer credits in the first year, increasing the time of degree completion, with an average of 20 credits in their first year, and 30 percent of FGCSs compared to 64 percent of their peers attained a bachelor's or higher [2]. This pattern of higher withdrawal rates, failure, and repeated grades directly contributes to extended timelines in engineering.

The Interaction of Generational Status and Gender

Building on the persistent generational gaps outlined above, the literature on the role of gender in engineering students' GPAs yielded mixed findings, particularly regarding its interaction with generational status. For instance, Aspelmeier et al. [12] found no significant gender-based differences in GPA, despite females reporting higher levels of academic adjustment and institutional attachment, and no association between generational status and gender. In contrast, women often reported lower confidence, yet their term GPA and overall GPA were significantly higher than those of male students [13, 14]. However, other large-scale and multi-institutional analyses have identified a persistent, albeit small, advantage for male students in introductory STEM courses. GPAs of male students were 0.1 to 0.19 GPA points higher than those of women on a four-point scale in fields such as biology, chemistry, physics, accounting, and economics [15, 16]. Further illustrating this, Simmons & Heckler [6] observed no mean GPA differences in introductory physics courses but noted that males in the algebra-based course had a broader grade distribution, with more A's (36%) and DFW's (18.7%). This was not observed in the calculus-based course, suggesting that gender differences varied by course rigor and format.

Intersectional interactions further complicate the literature, as the effects of generational status vary by gender and race. Strayhorn [17] used hierarchical multiple regression on national longitudinal data to show these influences on overall GPA, with Black male FGCSs having lower GPAs than their White and female counterparts. At the community college level, Holmes & Slate [3] confirmed that a main generational effect on GPA and student success rates differed by gender between FGCSs and CGCSs. For highly successful (A-grade) and moderately successful (B- to C-grade) male students, differences of 1.5% and 2.2%, respectively, were observed between FGCSs and CGCSs. Among female students, CGCSs were 4% more likely to achieve A grades but 4.4% less likely to fall within the B- to C grade range than FGCSs. In engineering-specific contexts, Boyce et al. [18] reported significant adverse outcomes for female FGCS, who earned lower first-semester GPAs and were 6.81 times as likely to receive a D, F, or W in chemistry as non-first-generation women.

Statement of the Problem

Despite strong evidence of persistent GPA gaps between FGCSs and CGCSs, recent literature often overlooks the extended academic trajectories of FGCSs reflected in lower completion rates within a four- to six-year graduation window [2, 3, 19]. This narrow framework underestimates FGCSs' persistence in engineering, where even CGCSs routinely exceed four years due to prescriptive curricula and high rigor. The existing literature highlights the need for analytical studies using contemporary datasets that are sufficiently long to extend beyond degree timelines and to comprehensively compare FGCSs and CGCSs, providing a picture of performance and persistence patterns.

The growing diversity of undergraduate populations amplifies interaction effects, in which the impact of generational status varies by other social identities, such as gender, making it the "rule rather than the exception" [17]. For instance, female FGCSs in engineering transfer at higher rates and take nearly a year longer to graduate than their non-FGCS peers [8]. This highlights the need for intersectional analysis, as relying on the single "first generation" term risks reproducing the inequality that researchers seek to mitigate [20].

Significance of the Study and Research Questions

The present study addresses critical research gaps in existing literature. First, the present study provides an 11-year longitudinal analysis of academic performance trends, using big data (8,835 individual undergraduate students) to offer a more robust understanding beyond single-year snapshots. Second, the present study applies an intersectional lens to examine how the interaction between generational status and gender influences GPAs. To achieve these goals, the following two research questions are:

1. What are the yearly trends in term and overall GPAs, and are the differences statistically significant?
2. How do generational status and gender interact to influence term and overall GPAs, and are patterns consistent across years?

METHODOLOGY

Academic performance of students in the present study was measured on a 4.0 GPA scale utilizing two distinct metrics to capture long- and short-term achievement. The overall GPA is the cumulative GPA through a specific fall semester, and the term GPA is the GPA earned within a single fall semester.

Statistical Analysis

The present study employs a cross-sectional quantitative design to analyze students' academic performance in multiple academic years. For the first research question, descriptive statistics were used to summarize means and trends for term and overall GPAs by generational status and academic year. Specifically, independent-samples t-tests or Mann-Whitney tests were used to compare FGCSs and CGCSs when the data were not normally distributed. For the second, two-way ANOVAs were conducted to examine main effects and interactions of generational status and gender on term and overall GPAs for each academic year. Assessing the normality of data distribution is a crucial step in statistical analysis, particularly for parametric tests such as the t-test and ANOVA. This test can be evaluated using significance tests of skewness and kurtosis, such as the Kolmogorov–Smirnov (K–S) and Shapiro–Wilk (S–W) tests. A normal distribution is perfectly symmetrical with a skewness and a kurtosis equal to zero, and typically visually appears as a bell-shaped curve [21]. A significant level of 0.05 was used for all tests in this study.

Data Collection

The sample comprised undergraduate students enrolled at the College of Engineering at USU, a public 4-year research institution in the United States. The dataset was filtered in three sequential steps, as shown in Figure 1, starting with an initial dataset of 10,511 anonymous undergraduate student records. First, the sample was refined to include only students with data in both the overall performance and the six-course mathematics GPA datasets, resulting in a sample of 9,104. Next, the analysis was limited to engineering students who had not changed their primary college, which yielded 9,023 participants. Finally, a time-based filter was applied to include only students admitted from the Fall 2011 semester onward. This process produced a final sample of 8,835 participants, reflecting gender, generational status, racial/ethnic, and enrollment categories.

Table 1 illustrates the number of enrolled engineering students each academic year from 2014 to 2024.

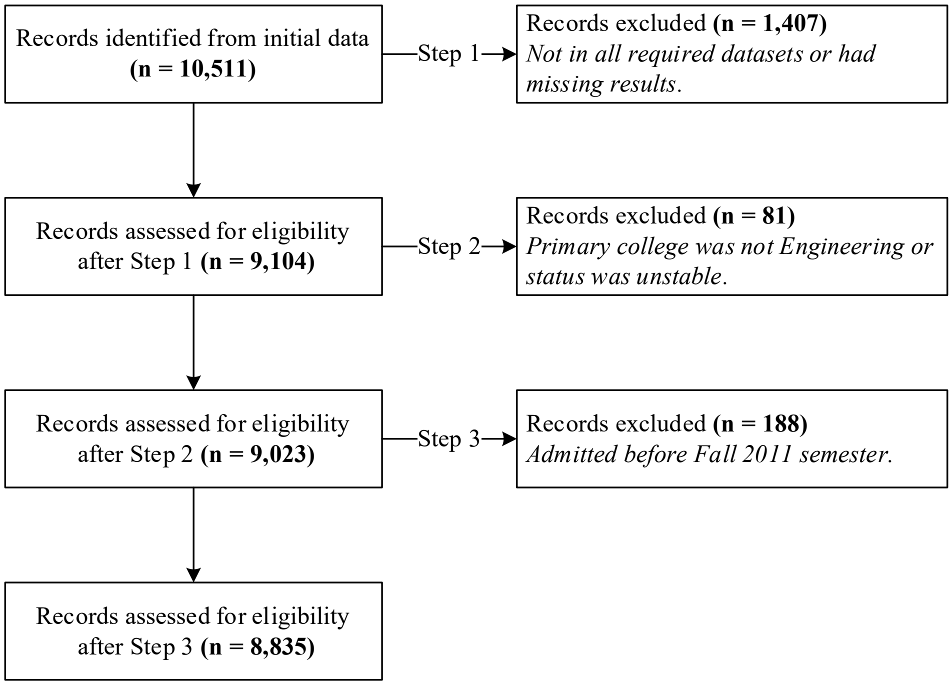

Figure 1. Flow Diagram for Participant Selection

Table 1. Total Enrollment of Engineering Students in the Present Study Each Year (*)

Academic Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Number students	1947	2334	2450	2469	2417	1812	1864	1816	1665	1619	1615

(*) The number of students sharply declined from 2417 in 2018 to 1812 in 2019 due to the Computer Science Department moving from the College of Engineering back to the College of Science, effective July 1, 2019, according to an institutional article.

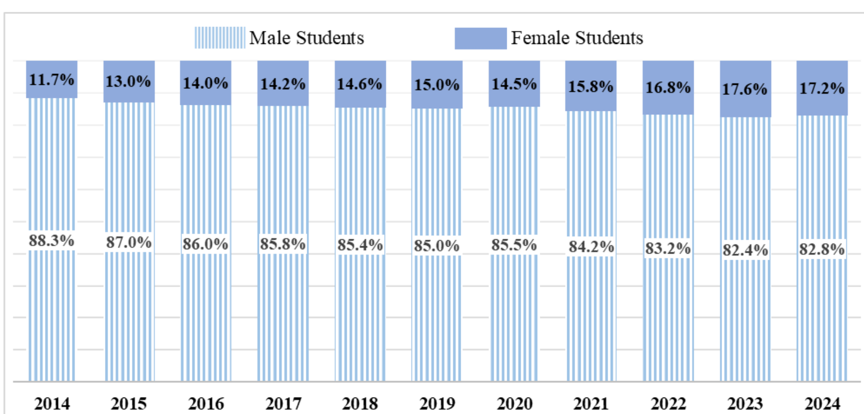

Figure 2. Annual Percentage of Male and Female Students (2014-2024)

Sample Characteristics

The demographic profile of engineering students during the study period highlighted persistent imbalances in both gender and generation. Regarding gender, the data in Figure 2 indicate a consistent predominance of male students, with their representation decreasing slightly from 88.3% in 2014 to 82.8% in 2024. In contrast, female students, though a small proportion, saw a gradual increase from 11.7% to 17.2% over the same period. By generational status, a growing disparity is evident in Figure 3, with the proportion of CGCSs rising from 81.9% in 2014 to 87.6% in 2024, while the representation of FGCSs declined from 18.1% to 12.4%. This evidence indicated that gender and generational status shaped the engineering student demographic, with male and continuing-generation students maintaining a dominant presence.

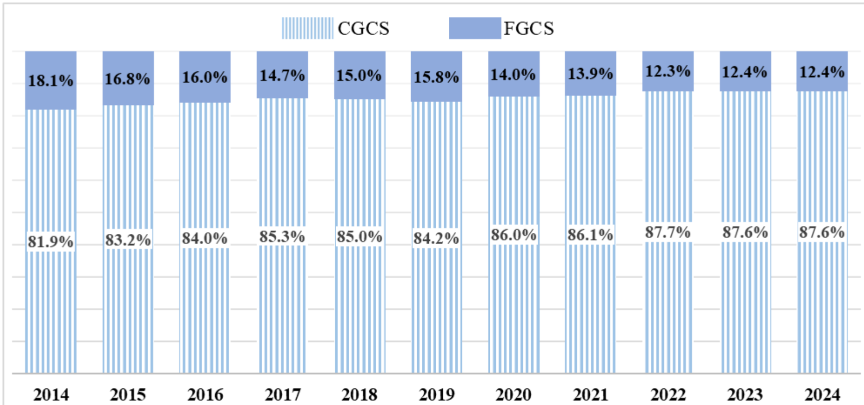

Figure 3. Annual Percentage of First- and Continuing-Generation Engineering Students (2014-2024)

The racial and ethnic diversity of the sample is illustrated in Figure 4. Most students identified as White, with percentages ranging from 87.2% in 2014 to 95.5% in 2024. Students who did not provide data constituted a smaller but variable segment, peaking at 8.0% in 2014 and declining to 0.7% in 2024. The "Other" category, defined as non-White racial/ethnic groups, fluctuated between 3.3% and 5.3% over the period. This suggested limited racial/ethnic diversity within the College of Engineering at USU.

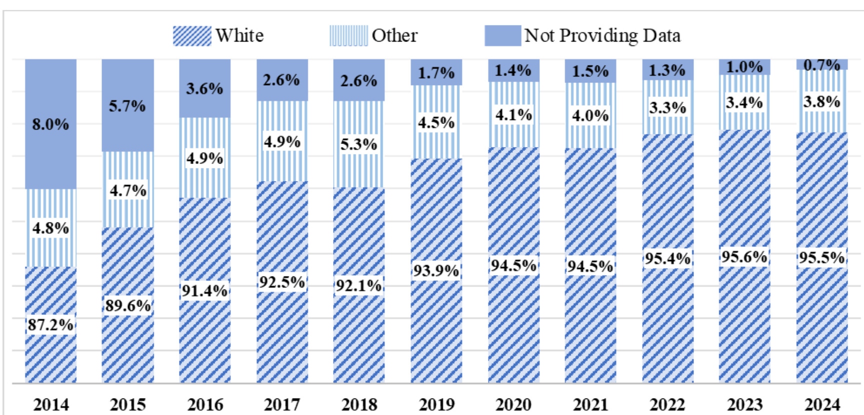

Figure 4. Annual Race/Ethnicity Distribution of Engineering Students (2014-2024)

Figure 5 shows that the enrollment distribution across engineering disciplines exhibited a distinct pattern over the 11 years. The Computer Science department averaged approximately 21% from 2014 to 2018, before transitioning from the College of Engineering to the College of Science in 2019. Other programs showed varied trends. The Mechanical and Aerospace Engineering department experienced significant growth, rising from 33.5% in 2014 to 52.0% in 2024 and suggesting strong retention. In contrast, the Biological Engineering department experienced a slight decline, from 8.7% in 2014 to 7.6% in 2024. The Electrical and Computer Engineering department and Civil and Environmental Engineering department maintained a relatively stable presence, with percentages fluctuating between 10.9% and 17.3%. The pre-engineering students group, known as the preparatory track, maintained a stable proportion throughout the period, ranging from 10.6% to 18.3% annually.

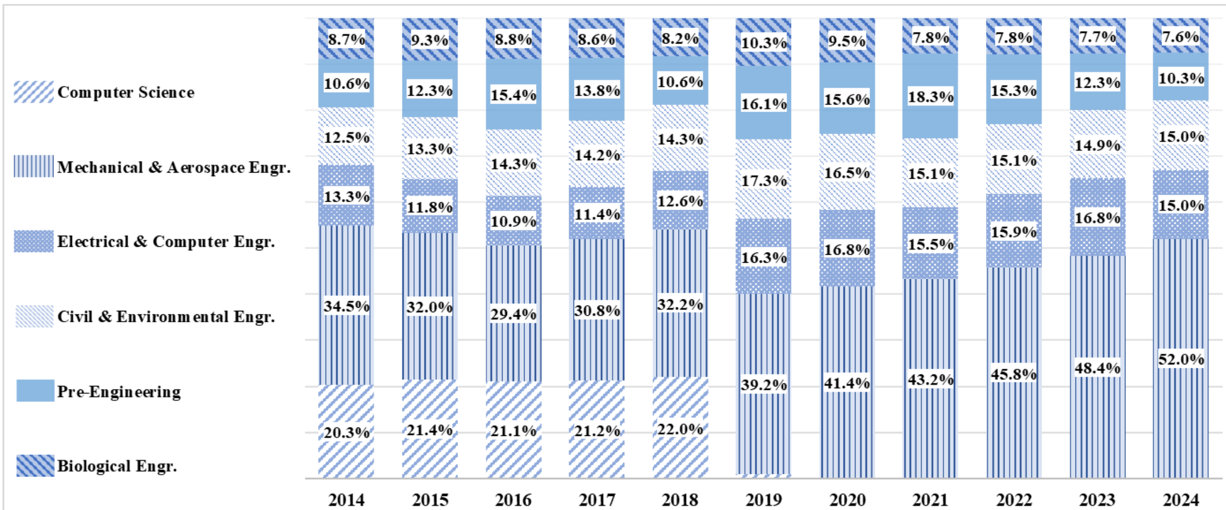

Figure 5. Annual Percentage of Students by Engineering Major (2014-2024)

Overall, the engineering student population during this period was predominantly male, continuing-generation, and White, with a substantial majority enrolled in mechanical and aerospace majors. These demographic and disciplinary distributions provided a critical context, particularly for understanding GPA trends and interaction effects.

RESULTS

The results, presented in Tables 2 and 3, address the first research question by examining the overall and term GPA gaps between FGCSs and CGCSs in engineering majors from 2014 to 2024. The results of descriptive statistics, including mean and standard deviation (SD), and Mann-Whitney tests (U-tests) due to non-normal distributions are interpreted in the following section.

Trends in GPA

Table 2. Results of Mann-Whitney Tests for Overall GPA by Generational Status

	Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
FGCSs	Mean	3.16	3.22	3.23	3.26	3.27	3.28	3.30	3.30	3.38	3.45	3.47
	SD	0.545	0.542	0.522	0.514	0.542	0.561	0.582	0.610	0.548	0.471	0.447
CGCSs	Mean	3.31	3.35	3.31	3.34	3.36	3.42	3.46	3.48	3.49	3.52	3.56
	SD	0.508	0.485	0.535	0.534	0.500	0.493	0.536	0.496	0.514	0.469	0.455
U-tests	z	-5.40	-4.77	-3.85	-3.71	-3.09	-4.07	-5.00	-4.97	-3.01	-2.71	-3.58
	p	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.003	0.007	0.000

Table 2 reveals a positive trajectory in overall GPA for both groups. The overall GPA of FGCSs increased from 3.16 to 3.47 (a net gain of 0.31 points), with SDs ranging from 0.447 to 0.610. Similarly, the overall GPA of CGCSs rose from 3.31 to 3.56 (a net gain of 0.25 GPA points), with SDs ranging from 0.455 to 0.536. However, strong evidence of a persistent achievement gap between FGCSs and CGCSs was also observed. CGCSs maintained a higher overall GPA than FGCSs, with the gaps ranging from 0.07 to 0.18 GPA points throughout the study period. The p-values for U-tests range from 0.000 to 0.007 ($p < 0.05$), indicating statistically significant differences between FGCSs and CGCSs in overall GPA. The Shapiro-Wilk p-values of 0.000 across most years ($p < 0.05$) confirmed that the distributions were non-normal, thereby justifying the use of U-tests.

Table 3. Results of Mann-Whitney Tests for Term GPA by Generational Status

	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
FGCSs	Mean	2.95	3.06	3.02	3.06	3.08	3.08	3.08	3.11	3.22	3.25	3.36
	SD	0.907	0.877	0.856	0.857	0.896	0.881	0.950	0.863	0.885	0.851	0.710
CGCSs	Mean	3.13	3.19	3.11	3.17	3.20	3.27	3.32	3.34	3.35	3.40	3.47
	SD	0.800	0.786	0.855	0.819	0.831	0.754	0.820	0.731	0.750	0.713	0.665
U-tests	z	-3.81	-3.25	-2.28	-2.61	-2.71	-3.42	-4.74	-3.95	-1.68	-2.94	-3.10
	p	0.000	0.001	0.023	0.009	0.007	0.001	0.000	0.000	0.092	0.003	0.002

Similar patterns for term GPA are presented in Table 3. FGCSs improved their term GPAs from 2.95 to 3.36 (net gain of 0.41 points), with the SDs ranging from 0.710 to 0.950, while CGCSs' term GPA increased from 3.13 to 3.47 (net gain of 0.34 GPA points), with the SDs between 0.665 and 0.853. Similar to the overall GPA, CGCSs outperformed FGCSs, with the gaps ranging from 0.09 to 0.24 GPA points. The p-values from U-tests range from 0.000 to 0.023 ($p < 0.05$) in most years, except 0.092 in 2022 (not statistically significant), indicating significance in 10 of 11 years. The gap in term GPA in 2022 is not statistically significant, suggesting temporary convergence, possibly due to external factors affecting both groups similarly.

However, closer examination of the two result tables reveals that the GPA gaps narrowed over the years for both metrics. The overall GPA gap decreased from 0.15 GPA points in 2014 to 0.09 GPA points in 2024, while the term GPA gap decreased from approximately 0.18 GPA points in 2014 to 0.11 GPA points in 2024. The widest disparities appeared in early years and during the COVID-19 period (e.g., 0.18 GPA points for overall GPA in 2021, 0.24 GPA points for term GPA in 2020), and the most significant narrowing occurred from 2021 to 2024, where FGCSs' gains outpaced those of CGCS (e.g., +0.25 GPA points for FGCSs' term GPA vs. +0.13 GPA points for CGCSs).

In summary, although GPA gaps narrowed over the 11 years, the results of RQ1 confirmed persistent, statistically significant differences between FGCSs and CGCSs. This underscores generational status as a key predictor of academic performance in engineering, prompting further investigation into potential interactions between gender and GPA.

The Interaction of Generational Status and Gender

Building on the findings from RQ1, the second research question examined the influence of generational status and gender on engineering students' GPAs using a series of two-way ANOVAs, with results presented in Tables 4 and 5. Levene's test indicated violations of homogeneity of variances ($p < 0.05$) in several years, including 2020-2021 for overall GPA and 2017-2023 for term GPA. Welch's F test and robust statistical methods were used to obtain reliable results.

Table 4. Results of Two-Way ANOVAs for Overall GPA by Gender and Generational Status

Year	**Effect**	**F (df_1, df_2)**	**p**	**Welch's F (df_1, df_2) (*)**	**Welch's p (**)**	**η^2**	**Levene's Test (p)**
2014	Gender	0.10 (1, 1942)	0.753	-	-	0.000	0.121
	Generational Status	13.73 (1, 1942)	0.000	-	-	0.007	0.121
	Gender×Generational Status	0.30 (1, 1942)	0.583	-	-	0.000	0.121
2015	Gender	3.20 (1, 2330)	0.074	-	-	0.001	0.349
	Generational Status	9.30 (1, 2330)	0.002	-	-	0.004	0.349
	Gender×Generational Status	0.00 (1, 2330)	0.950	-	-	0.000	0.349
2016	Gender	6.83 (1, 2445)	0.009	-	-	0.003	0.142
	Generational Status	6.27 (1, 2445)	0.012	-	-	0.003	0.142
	Gender×Generational Status	0.58 (1, 2445)	0.446	-	-	0.000	0.142
2017	Gender	5.46 (1, 2464)	0.020	-	-	0.002	0.068
	Generational Status	6.33 (1, 2464)	0.012	-	-	0.003	0.068
	Gender×Generational Status	0.99 (1, 2464)	0.319	-	-	0.000	0.068
2018	Gender	5.42 (1, 2412)	0.020	-	-	0.002	0.186
	Generational Status	7.06 (1, 2412)	0.008	-	-	0.003	0.186
	Gender×Generational Status	0.29 (1, 2412)	0.592	-	-	0.000	0.186
2019	Gender	2.67 (1, 1808)	0.102	-	-	0.001	0.066
	Generational Status	12.00 (1, 1808)	0.001	-	-	0.007	0.066
	Gender×Generational Status	0.23 (1, 1808)	0.633	-	-	0.000	0.066
2020	Gender	5.41 (1, 1860)	0.020	23.72	0.000	0.003	0.000
	Generational Status	18.98 (1, 1860)	0.000	17.59	0.000	0.010	0.000
	Gender´Generational Status	1.68 (1, 1860)	0.195	-	-	0.001	0.000
2021	Gender	2.88 (1, 1812)	0.090	5.14	0.024	0.002	0.000
	Generational Status	15.76 (1, 1812)	0.000	20.41	0.000	0.009	0.000
	Gender×Generational Status	0.02 (1, 1812)	0.902			0.000	0.000
2022	Gender	0.43 (1, 1661)	0.514	-	-	0.000	0.265
	Generational Status	7.50 (1, 1661)	0.006	-	-	0.004	0.265
	Gender×Generational Status	0.74 (1, 1661)	0.389	-	-	0.000	0.265
2023	Gender	2.61 (1, 1615)	0.107	-	-	0.002	0.080
	Generational Status	2.86 (1, 1615)	0.091	-	-	0.002	0.080
	Gender×Generational Status	0.06 (1, 1615)	0.806	-	-	0.000	0.080
2024	Gender	0.93 (1, 1611)	0.335	-	-	0.001	0.363
	Generational Status	5.94 (1, 1611)	0.015	-	-	0.004	0.363
	Gender×Generational Status	0.85 (1, 1611)	0.356	-	-	0.001	0.363

**Welch's F (or robust statistic) is used when Levene's $p < 0.05$;*
***Corresponding Welch's p-value.*

As confirmed by the U-test results, a main effect of generational status on overall GPA is consistent across Table 4, with F values ranging from 5.94 to 20.41 and $p < 0.05$ in 10 out of 11 years, except in 2023 ($F(1, 1615) = 2.86$, $p = 0.091$). Meanwhile, in Table 5, this effect on term GPA was less consistent, with F values ranging from 4.91 to 15.96 and $p < 0.05$ in 2014 and in

2017–2023, but not significant in 2015–2016 and 2024. The peak effects for both metrics occurred during 2020-2021, with F > 17 and $\eta^2 > 0.009$ for overall GPA and F > 14 and $\eta^2 > 0.006$ for term GPA, possibly reflecting pandemic impacts. However, the magnitude of this effect, measured by Eta-squared (η^2), was negligible (< 0.010), accounting for less than 1% of the total variance.

Table 5. Results of Two-Way ANOVAs for Term GPA by Gender and Generational Status

Year	Effect	F (df_1, df_2)	p	Welch's F (df_1, df_2) (*)	Welch's p (**)	η^2	Levene's Test (p)
2014	Gender	0.48 (1, 1943)	0.487	-	-	0.000	0.158
	Generational Status	5.05 (1, 1943)	0.025	-	-	0.003	0.158
	Gender×Generational Status	0.04 (1, 1943)	0.835	-	-	0.000	0.158
2015	Gender	0.98 (1, 2330)	0.323	-	-	0.000	0.555
	Generational Status	3.45 (1, 2330)	0.063	-	-	0.001	0.555
	Gender×Generational Status	0.08 (1, 2330)	0.779	-	-	0.000	0.555
2016	Gender	3.44 (1, 2445)	0.064	-	-	0.001	0.138
	Generational Status	2.29 (1, 2445)	0.130	-	-	0.001	0.138
	Gender×Generational Status	0.22 (1, 2445)	0.640	-	-	0.000	0.138
2017	Gender	3.38 (1, 2465)	0.066	12.51	0.000	0.001	0.044
	Generational Status	3.70 (1, 2465)	0.055	4.91	0.027	0.001	0.044
	Gender×Generational Status	0.30 (1, 2465)	0.583	-	-	0.000	0.044
2018	Gender	5.98 (1, 2413)	0.015	10.60	0.001	0.002	0.011
	Generational Status	1.90 (1, 2413)	0.168	5.21	0.023	0.001	0.011
	Gender×Generational Status	0.16 (1, 2413)	0.688	-	-	0.000	0.011
2019	Gender	10.62 (1, 1808)	0.001	8.74	0.003	0.006	0.000
	Generational Status	1.98 (1, 1808)	0.159	11.04	0.001	0.001	0.000
	Gender×Generational Status	3.31 (1, 1808)	0.069	3.31 (1, 1808)	0.069	0.002	0.000
2020	Gender	5.12 (1, 1860)	0.024	18.59	0.000	0.003	0.000
	Generational Status	15.59 (1, 1860)	0.000	14.36	0.000	0.008	0.000
	Gender´Generational Status	0.94 (1, 1860)	0.333	-	-	0.001	0.000
2021	Gender	0.82 (1, 1811)	0.367	1.24	0.267	0.000	0.000
	Generational Status	11.56 (1, 1811)	0.001	15.96	0.000	0.006	0.000
	Gender×Generational Status	0.01 (1, 1811)	0.924	-	-	0.000	0.000
2022	Gender	0.04 (1, 1661)	0.845	0.90	0.344	0.000	0.016
	Generational Status	6.41 (1, 1661)	0.011	3.77	0.053	0.004	0.016
	Gender×Generational Status	1.57 (1, 1661)	0.211	-	-	0.001	0.016
2023	Gender	0.06 (1, 1615)	0.800	2.51	0.114	0.000	0.006
	Generational Status	7.22 (1, 1615)	0.007	6.04	0.015	0.004	0.006
	Gender×Generational Status	0.83 (1, 1615)	0.364	-	-	0.001	0.006
2024	Gender	1.78 (1, 1611)	0.182	-	-	0.001	0.059
	Generational Status	2.68 (1, 1611)	0.102	-	-	0.002	0.059
	Gender×Generational Status	0.03 (1, 1611)	0.869	-	-	0.000	0.059

**Welch's (or robust statistic) F is used when Levene's p < 0.05;*
***Corresponding Welch's p-value.*

In contrast, the main effect of gender was inconsistent across both metrics. For overall GPA, F values ranged from 0.10 to 23.72, and p < 0.05 in 2016-2018 and 2020-2021; however, it was not statistically significant in other years. For term GPA, the F values were from 0.48 to 18.59

and were significant ($p < 0.05$) only in 2017-2020. In both metrics, eta-squared (η^2) was negligible (0.000 to 0.003), indicating limited practical impact.

Crucially, it is apparent from both Tables 4 and 5 that no significant interactions were observed in any year, with $F = 0.00\text{-}3.31$, $p = 0.069\text{-}0.950$, and $\eta^2 < 0.002$. Although violations of homogeneity of variances were detected in many years, the p-values were above 0.10 (well above the conventional significance threshold of 0.05), except for the 2019 term GPA ($p = 0.069$). A bootstrapped procedure ($N = 1000$) was conducted for this case, confirming non-significance.

In summary, within the College of Engineering at USU, the results for RQ2 confirmed that generational status is a primary predictor of GPA, whether in the term or overall GPA, and that these gaps do not vary by gender, nor is there a significant interaction.

DISCUSSIONS

This study's findings show an achievement gap in engineering for FGCSs from 2014 to 2024 that is consistent across genders and also highlight a narrowing of the GPA gap between FGCSs and CGCSs. These insights extend the literature on patterns within a Mountain West regional public university setting, where continuing-generation, White, and male students (87%-95%), potential institutional supports, and the COVID-19 pandemic's disruptions shape outcomes. Although the College of Engineering at USU comprises five fields, including Environmental Engineering, Biological Engineering, Electrical Engineering, Mechanical Engineering, and Civil Engineering, this research combined them into a single analytical group. This unified approach was selected to maintain the statistical power required for a comprehensive 11-year study and to identify broad institutional patterns, allowing researchers to discern trends that extend beyond departmental differences.

Answering RQ1, the results clearly confirm the literature on FGCSs’ underperformance relative to CGCSs. The study found that statistically significant GPA differences persisted over 11 years for overall GPAs (0.07 to 0.18 GPA points; $p < 0.05$) and in 10 of 11 years for term GPAs (0.09 to 0.24 GPA points; $p < 0.05$). The average gap, starting at 0.15 GPA points overall in 2014 and peaking at 0.18 GPA points for term GPA, falls within the literature range of 0.1 to 0.3 points [2, 3]. The most significant observation is the performance improvement, with FGCSs outperforming CGCSs: +0.31 vs. +0.25 GPA points for overall GPA and +0.41 vs. +0.34 GPA points for term GPA, respectively. Moreover, the observed GPA gap convergence in the present study, from 0.15 to 0.09 GPA points overall and from 0.18 to 0.11 GPA points for term GPAs, suggests a powerful, decisive shift in academic trajectory that extends beyond single-year analyses, such as those by Weisen et al. [4]. This also supports the acclimation hypotheses of Tibbetts et al. [14], who argued that as students become acclimated to college, they may gain a better understanding of the skills and study habits necessary for successful degree completion.

In addition, the longitudinal and cross-sectional analyses directly address a critical oversight in the recent literature: narrow four- to six-year frameworks obscure authentic trajectories of FGCSs within engineering's rigorous curricula [2]. The multi-year data analysis to improve the generalizability of single-year results revealed that FGCSs’ early-semester grades did not improve at the same rate as CGCSs and sometimes worsened [3, 14].

Furthermore, the observed narrowing of the GPA gap occurs within a decade of intensified first-generation–focused institutional support from the early stages of education. For instance, the

Aggie UP Program at USU prepares FGCSs through mentorship by first-generation faculty and staff and through early campus integration. The Aggie First Scholars Program fosters a sense of belonging and builds cultural capital and institutional knowledge through community engagement and specialized courses in Navigating College and Applied Leadership. TRIO Student Support Services (SSS), a federally funded TRIO program, provides structured support to enhance FGCSs' academic, personal, and social skills. The program focuses on academic tutoring, academic planning, financial literacy guidance, and specialized resources and navigational coursework. While this study does not assess causal program effects, the alignment between GPA convergence and the presence of multi-level support provides important contextual grounding for interpreting long-term performance trends among FGCSs.

Nguyen & Nguyen [20] emphasized the vital role of intersectionality, including gender and generational status, as a framework for a deeper understanding of social inequalities and for shaping students' experiences and outcomes. Despite this, two-way ANOVAs in this study revealed no significant generational status-gender interactions ($F = 0.00–3.31$; $p = 0.069–0.950$; $\eta^2 < 0.002$) across all years, even with robust Welch's adjustments for variance heterogeneity. The null findings stand in sharp contrast to substantial evidence of interaction effects in the literature, including amplified GPA deficits among Black male FGCSs [3, 17]. However, this supports Nguyen and Nguyen's [20] argument that intersectional dynamics are challenging to observe in the homogeneity of the engineering context, with 87.2%-95.5% White and 82.8%-88.3% male students, which likely obscures the detection of interaction effects.

These results indicate that FGCSs' GPA gaps in engineering are highly context-specific, with generational status remaining as the primary predictor at the College of Engineering at USU. The main effect of generational status remained dominant ($F = 5.94–20.41$; $p < 0.05$ in 10 out of 11 years; $\eta^2 = 0.001–0.010$), overshadowing inconsistent gender effects ($F = 0.10–23.72$; significant only in 2016–2018 and 2020–2021 for overall GPA; $\eta^2 < 0.003$). Gender effects in academic performance are conditional on unmeasured factors, aligning with STEM research on confidence and affective variables. For example, Harackiewicz et al. [13] observed that psychological factors, such as confidence, differed by gender and did not necessarily translate into differences in course grades. Similarly, Tibbetts et al. [14] found that the psychological challenges related to cultural mismatch are unique to FGCSs and do not appear to be shared by women in the same context, suggesting that these challenges are not parallel.

Furthermore, the COVID-19 pandemic marked a critical inflection point in FGCSs' achievement gaps, with term GPA differences widening to 0.24 GPA points in 2020 and overall GPA to 0.18 GPA points in 2021. Peak ANOVA F-values (F-values > 17; $\eta^2 > 0.009$) during 2020–2021 underscore FGCSs' vulnerabilities. This pattern was also observed by Boyce et al. [18], who documented that, in Fall 2021 (a pandemic-era cohort), FGCSs enrolled with fewer pre-matriculation credits, more learning concerns, and lower first-semester grades than their peers. Due to the immediate transition to fully remote or hybrid learning, such as the emergency switch to online platforms, Boyce et al. [18] explained that profound societal disruptions occurred within education.

In contrast, multiple pre-pandemic semesters showed that CGCSs' GPAs typically improved, consistent with the acclimation hypotheses proposed by Tibbetts et al. [14]. Their strong, established foundations, including academic habits, cultural capital, and family support, helped them withstand sudden external impact, with the sustained growth in both GPAs. FGCSs, however, faced pre-existing academic challenges and financial gaps [4, 10, 13], leading to stagnation rather than progress. This differential academic performance trajectory highlights the unique susceptibility of FGCSs, including feelings of cultural mismatch [13, 14], and the lack of familial cultural capital needed to navigate college [11]. They were disproportionately vulnerable to the "unprecedented external shock" of the COVID-19 pandemic and its accompanying educational disruptions [18], while CGCSs maintained momentum.

IMPLICATION

The findings from this study offer several implications for engineering education, particularly for supporting FGCSs. First, generational status remains a significant predictor of GPAs, yet the observed narrowing of the gap from 0.18 to 0.09 GPA points provides evidence that closing the academic performance gap is achievable within a supportive institutional environment. Moreover, the observed post-2021 convergence trajectory demonstrates that FGCSs can acclimate and recover when provided with structured support. These results underscore the importance of maintaining and strategically expanding programs such as the Aggie UP Program, the Aggie First Scholars Program, and the TRIO SSS as a part of a multifaceted approach to enhance equity and improve long-term academic performance for FGCSs in engineering.

Second, larger GPA gaps occur in the early semesters, indicating that FGCSs experience their greatest academic vulnerabilities during the initial transition to university. This period is a critical juncture, and early interventions should address gaps in cultural capital and cultural mismatch and expand beyond existing supports, such as gateway course support and personalized instructional support in gateway mathematics.

Finally, the significant widening of the GPA gap during the COVID-19 period underscores FGCSs' unique susceptibility to external shocks. The call for institutions should consider adding institutional mechanisms, interventions, mental health resources, and pedagogical strategies to create a structural buffer against external shocks and protect marginalized students.

LIMITATIONS

This study has four limitations. The first limitation is that the data analyzed were drawn exclusively from a single institution, the College of Engineering at USU, influenced by specific academic policies and regional demographics. This contextual constraint limits the generalizability of the results when applied to institutions with larger, more racially diverse, or urban populations. The second limitation stems from the sample's internal homogeneity across departments and demographics. This constrains the analysis of department-specific grading and limits the capacity to grasp how students' backgrounds and identities interact.

The third limitation is methodological. The analysis primarily relies on comparing cohorts each year, which prevents the study from drawing definitive conclusions about the growth and adaptation of individual students throughout their academic lifecycle. Finally, focusing solely on term and overall GPA as the primary metrics for academic achievement is limited because these measures do not capture the deeper, long-term indicators of engineering success. This may reflect initial obstacles but excludes other important metrics of success, such as cumulative earned credits, degree attainment, and transfer behavior, all of which provide a fuller picture of persistence, especially for FGCSs, which often have lower retention rates and longer completion times.

CONCLUSIONS

A quantitative method was used to analyze the academic performance of 8,835 engineering students at USU from 2014 to 2024, with data stratified by generational status, gender, race/ethnicity, and major. The findings showed a consistent, statistically significant gap in overall and term GPAs between FGCSs and CGCSs throughout nearly the entire 11-year study period, confirming established trends in challenging STEM fields. Crucially, the gap narrowed throughout the analysis period, with a larger net GPA gain for FGCSs, suggesting that the gaps are not immutable, as FGCSs can adapt to the university environment.

However, the highest GPA gaps during the 2020–2021 period were a critical inflection point, highlighting the FGCSs' vulnerability to systemic shocks. FGCSs were affected by the COVID-19 pandemic and the abrupt shift to remote learning, further exacerbating pre-existing educational inequalities. Finally, the two-way ANOVAs confirmed that generational status is the most robust predictor of academic performance in the engineering context, with the main effects of gender and the interaction effect not significant. This suggests that while women and FGCSs both face challenges, the disadvantages of being first-generation operate independently (or additively) rather than dramatically magnifying the effect of being female on GPA outcomes at USU.

Furthermore, this analysis is constrained by its limited sample diversity, which may prevent the capture of intersectional vulnerabilities identified in prior research. The inconsistent effects of gender within a college's homogenous population highlight a critical methodological point: additive models obscure the interaction between identity and context. This calls for subsequent research to move beyond simple main-effect analyses and interaction effects to examine psychological factors and how they interact with the program structure (or context) to produce outcomes. In light of these findings, future research must move beyond the current limitations of single-institution studies and homogenous cohorts by pursuing multi-institutional research that encompasses diverse student populations. This broader approach is necessary to uncover latent effects, such as academic outcomes associated with intersecting identities; to validate the long-term effectiveness of targeted interventions; and to disaggregate outcomes by academic major to determine whether certain engineering disciplines provide more inclusive environments or different success trajectories for FGCSs.

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REFERENCES

[1] U.S. Department of Education, "Higher Education Act of 1965, Section 402A," Washington, DC, USA, 1965. [Online]. Available: https://www2.ed.gov/about/offices/list/ope/trio/trio-hea.pdf

[2] X. Chen, "First generation students in postsecondary education: A look at their college transcripts," U.S. Department of Education, National Center for Education Statistics, Washington, DC, USA, Tech. Rep. NCES 2005–171, 2005.

[3] D. L. Holmes and J. R. Slate, “Differences in GPA by gender and ethnicity/race as a function of first-generation status for community college students,” *Global Journal of Human-Social Science Research*, vol. 17, no. 3, pp. 1–5, 2017.

[4] S. Weisen, T. Do, M. C. Peczuh, A. S. Hufnagle, and G. Maruyama, “How are first-generation students doing throughout their college years? An examination of academic success, retention, and completion rates,” *Analyses of Social Issues and Public Policy*, vol. 24, no. 3, 2024, doi: 10.1111/asap.12413.

[5] E. A. Canning, M. White, and W. B. Davis, “Growth mindset messages from instructors improve academic performance among first-generation college students,” *CBE—Life Sciences Education*, vol. 23, no. 2, art. ar15, 2024. doi: 10.1187/cbe.23-07-0131.

[6] A. B. Simmons and A. F. Heckler, “Grades, grade component weighting, and demographic disparities in introductory physics,” *Physical Review Physics Education Research*, vol. 16, no. 2, art. 020125, 2020. doi: 10.1103/PhysRevPhysEducRes.16.020125.

[7] G. Dietz and J. C. Bullington-Miller, “WIP: Exploring first generation engineering technology students acquisition of the engineering identity,” in *Proc. 2024 ASEE Annual Conference & Exposition*, Portland, OR, USA, 2024, doi: 10.18260/1-2--48303.

[8] J. Perez, “Understanding the intersection of first-generation degree seeking women, engineering, and public universities,” in *Proc. 2019 ASEE Annual Conference & Exposition*, Tampa, FL, USA, 2019, doi: 10.18260/1-2--33482.

[9] S. Torvi, B. Nepal, and M. Johnson, “Improving academic performance of first-generation students: A case study of mentoring program,” in *Proc. 2022 ASEE Annual Conference & Exposition*, Minneapolis, MN, USA, 2022, doi: 10.18260/1-2--40659.

[10] J. Engle and V. Tinto, “Moving beyond access: College success for low-income, first-generation students,” Pell Institute for the Study of Opportunity in Higher Education, Washington, DC, USA, Tech. Rep. ED504448, 2008.

[11] E. F. Cataldi, C. T. Bennett, and X. Chen, “First-generation students: College access, persistence, and postbachelor's outcomes,” National Center for Education Statistics, Washington, DC, USA, Tech. Rep. NCES 2018-421, 2018.

[12] 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*, vol. 53, no. 7, pp. 755–781, 2012. doi: 10.1007/s11162-011-9252-1.

[13] J. M. Harackiewicz, E. A. Canning, Y. Tibbetts, C. J. Giffen, S. S. Blair, D. I. Rouse, and J. S. Hyde, “Closing the social class achievement gap for first-generation students in undergraduate biology,” *Journal of Educational Psychology*, vol. 106, no. 2, pp. 375–389, 2014, doi: 10.1037/a0034679.

[14] Y. Tibbetts, J. M. Harackiewicz, E. A. Canning, J. S. Boston, S. J. Priniski, and J. S. Hyde, “Affirming independence: Exploring mechanisms underlying a values affirmation intervention for first-generation students,” *Journal of Personality and Social Psychology*, vol. 110, no. 5, pp. 635–659, 2016, doi: 10.1037/pspa0000049.

[15] R. L. Matz, B. P. Koester, S. Fiorini, G. Grom, L. Shepard, C. G. Stangor, B. Weiner, and T. A. McKay, "Patterns of gendered performance differences in large introductory courses at five research universities," *AERA Open*, vol. 3, no. 4, pp. 1–12, 2017, doi: 10.1177/2332858417743754.

[16] K. Denaro, M. Molinaro, S. Fiorini, R. L. Matz, C. Mead, M. Motika, N. Tarchinski, M. V. Medinaceli, W. C. Byrd, B. Koester, H. R. Lee, T. McKay, and B. K. Sato, "A multi-institutional cluster analysis to identify groups of courses with exemplary opportunity gaps for undergraduate students in the biological sciences," *CBE—Life Sciences Education*, vol. 23, no. 4, art. ar47, 2024. doi: 10.1187/cbe.24-02-0051.

[17] T. L. Strayhorn, "Factors influencing the academic achievement of first-generation college students," *NASPA Journal*, vol. 43, no. 4, pp. 82–111, 2006. doi: 10.2202/1949-6605.1724.

[18] H. Boyce, M. J. Szoo, P. A. DiMilla, and R. Reisberg, "Examining first-year student success and attitudes during challenging times," in *Proc. 2023 ASEE Annual Conference & Exposition*, Baltimore, MD, USA, 2023, doi: 10.18260/1-2--43539.

[19] R. A. Costello, S. Salehi, C. J. Ballen, and E. Burkholder, "Pathways of opportunity in STEM: Comparative investigation of degree attainment across different demographic groups at a large research institution," *International Journal of STEM Education*, vol. 10, no. 1, art. 46, 2023. doi: 10.1186/s40594-023-00436-5.

[20] T.-H. Nguyen and B. M. D. Nguyen, "Is the 'first-generation student' term useful for understanding inequality? The role of intersectionality in illuminating the implications of an accepted—yet unchallenged—term," *Review of Research in Education*, vol. 42, no. 1, pp. 146–176, 2018, doi: 10.3102/0091732x18759280.

[21] A. P. Field, *Discovering Statistics Using SPSS: (And Sex, Drugs and Rock 'n' Roll)*, 3rd ed. London, UK: SAGE Publications, 2009.