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Analysis of First-Generation Engineering Students Engagement and its Relation to their Academic Performance*

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First-generation college (FGC) students differ from their continuing-generation counterparts in many aspects, such as having a lower grade point average (GPA), a higher likeliness to switch majors out of science, technology, engineering, and mathematics (STEM), a lower level of engagement in and a lower likeliness to graduate in STEM majors. Looking to take steps to aid FGC engineering students with their current struggles, the present study aimed to investigate the educational activities they were engaging in, and how these activities relate to their GPA, an overall measurement of students' academic performance. A total of 28 FGC engineering students at the authors' institution took the National Survey of Student Engagement (NSSE). Student responses were related to 4 themes and 10 engagement indicators (EIs) of the NSSE and were related to student GPA as well. It was found that FGC engineering students had high levels of engagement in educational activities related to two themes (learning with peers and academic challenge) and two EIs (learning strategies and discussions with diverse others). Example learning strategies that students use include pre-reading the course material prior to a class and summarizing after class what they have learned in a class period. On the other hand, from the present study it was also found that FGC engineering students had a low level of engagement in the experiences with the faculty theme and the student-faculty interaction ET (i.e., student interaction with faculty). Student GPA was statistically significantly correlated with the supportive environment EI with a moderate Spearman correlation coefficient of 0.414 and p-value < 0.05.

Keywords: student engagement; first-generation college (FGC) students; engineering; descriptive and correlational analysis

1. Introduction

1.1 First-generation College (FGC) Students in General

The U.S. Department of Education defines first-generation college (FGC) students as those undergraduates whose parents' highest level of education is a high school diploma or less or whose parents have never enrolled in postsecondary education [1]. Relevant research found that FGC students differ from their continuing-generation counterparts in many aspects [2–5]. For example, FGC students, in general, feel less supported and engage less than their continuing-generation peer [5]. FGC students in science, technology, engineering, and mathematics (STEM) majors show a 0.15 lower grade point average (GPA) than continuing-generation students and a 6% likelihood of graduating college in a STEM major [6, 7]. First-generation students also switch majors out of STEM more often than their continuing-generation counterparts [8].

The above-described differences between first- and continuing-generation students call for in-depth research on what specific activities students are engaging in and how these activities relate to student GPA, an overall measurement of students' academic performance. This is because students' academic performance is directly linked with their engagement activities, which could be in their classes (where they ask questions, set goals, and collaborate with others) or outside of the classroom (where they join clubs, work with faculty on projects, and utilize learning resources within their institution). Relevant studies show that both first- and continuing-generation students engage in the same specific activities, but the engagement levels for first-generation students are lower [5]. In classrooms where instructors encourage engagement by promoting activities such as reflective thinking, interaction within the classroom, and activation of previous knowledge, students of all backgrounds were more engaged both cognitively and behaviorally [9].

1.2 First-generation College (FGC) Students in Engineering Majors

Recent and past studies relating to engineering students' engagement activities choose to analyze students' generational status and identity development [10–14]. Studies in this area of research often looked to relate different variables to student engagement as opposed to isolating it as the lone

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variable. Fairly recent studies have related student engagement to social capital, student support at an institutional and personal level, and student activities such as studying [15–18].

A few studies comparing first- and continuing-generation students in engineering found differences between the two groups in involvement, seeking help from others, and views on college as a whole [15, 18–20]. These studies had themes consistent with student engagement, even if they were not explicitly identified as student engagement. As a whole, these studies indicate that differences do exist between first- and continuing-generation students in engineering and provide some insights into students' perceptions. Some studies also looked at specific activities that students engage in; however, an overall big picture specific to the engagement of FGC engineering students is still lacking in the literature. The present study looks to bridge this research gap by providing an overall big picture of student engagement. The innovation and contribution of the present study are further described in the following sub-section.

1.3 The Innovation and Contribution of the Present Study

Current literature discussing student engagement of FGC students as a whole studied a wide number of topics and variables. Some studies looked at the engagement of populations of FGC students in STEM fields [21, 22]. Other studies looked at only one or two specific types of engagement rather than engagement as a whole [23, 24]. The present study bridges the current research gap by investigating the overall engagement experiences of FGC students in engineering and relating these experiences to student GPA, an overall measurement of students' academic success.

In addition, in the vast majority of existing studies, student engagement was included as one of the several different variables to analyze, and student engagement was related to educational relationships, seeking resources, or persistence [19, 25]. Our literature review shows that only one recent study [20] dealt with several similar factors (not all factors) and topics of student engagement as the present study. That study [20] was also limited to student engagement in the classroom only, rather than both inside and outside the classroom. Using observations and surveys where students self-reported their engagement experiences throughout a class period, Mazumder et al. [20] found that for first- and continuing-generation students in engineering, academic success was weakly correlated with student engagement. Comparing first- and continuing-generation students in engineering, the engagement variable showed only a slightly significant difference between the two groups. Mazumder et al. [20] stated that they did not expect these research findings and recommended more work to be done in this area of study. The present study adds to the current knowledge base by using a comprehensive, widely accepted survey instrument to examine (confirm or deny, correct or clarify) the existing research findings. The survey instrument employed in the present study was the National Survey of Student Engagement (NSSE) [26, 27], which consists of 43 questions that detail different educational activities students have both within and outside the classroom. The NSSE asks students how often they engage in these activities. Questions on the NSSE are divided into 4 different themes, and each theme is associated with 2–4 engagement indicators (EIs) [26, 27].

In the remaining sections of this paper, described first are the research questions of the present study, student participants, data collection, and data analysis methods. Then, the results from the Shapiro-Wilk normality test are presented, followed by a descriptive and correlational analysis of student engagement. The limitations of the present study are discussed. Conclusions are made at the end of the paper.

2. Methods

2.1 Research Questions

The present study was conducted in the College of Engineering at the authors' institution with the following two research questions:

1. What is the engagement experience of FGC engineering students?
2. How does student engagement of FGC engineering students relate to their GPA?

Note that the scope of the present study is limited to finding out the engagement experience of FGC engineering students. Finding out why these students choose or do not choose any particular engagement activities is beyond the scope of the present study and will be addressed in future work.

2.2 Student Participants

A quantitative research method was employed in the present study to answer the above research questions. Student participants were from the College of Engineering at the authors' institution, a public research university in the Mountain West region in the U.S. They were sent an invitation to participate via their preferred student email. Interested students were then asked to complete a screening survey that determined student generational status and major. Students who were first-generation students and enrolled in an engineering major

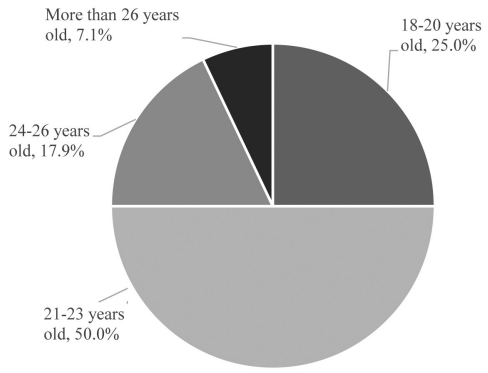

Fig. 1. Age distribution of student participants.

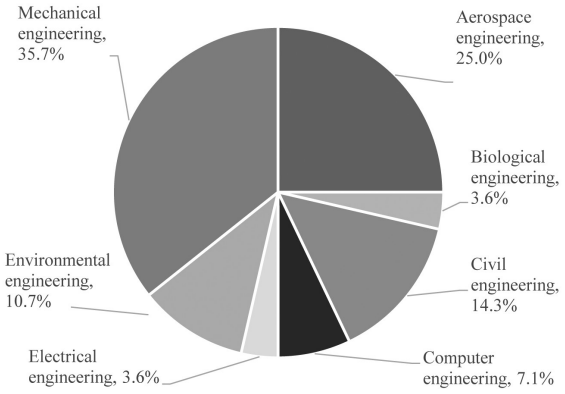

Fig. 2. Distribution of student participants' majors.

were then sent an Informed Consent form approved by an Institutional Review Board. As a result, a total of 28 students signed the Informed Consent form and were included in the present study as student participants. Figs. 1 and 2 show, respectively, the ages and declared majors of student participants.

As can be seen from Fig. 1, 50% of student participants were 21–23 years old, and 17.9% were 24–26 years old. Fig. 2 shows that most student participants were in mechanical engineering (35.7%), aerospace engineering (25.0%), or civil engineering (14.3%) majors. In addition, the study sample contained roughly the same number of participants in the sophomore, junior, and senior class levels. With regard to gender, 1 student chose not to identify, 17 chose to identify as male, and 10 chose to identify as female.

2.3 Data Collection and Analysis

After providing their informed consent, student participants were asked to complete the National Survey of Student Engagement (NSSE) [26, 27]. Students were also given an Amazon gift card as compensation for their time in responding to the NSSE. The NSSE consists of 43 questions in 4 themes. Each theme contains a certain number of engagement indicators (EIs). Table 1 shows the themes and associated engagement indicators included in the NSSE.

Table 1. Themes and associated engagement indicators

Theme	Engagement indicator (EI) for each theme
Academic challenge (AC)	Higher-order learning (HOL) Reflective and integrative learning (RIL) Learning strategies (LES) Quantitative reasoning (QUR)
Learning with peers (LP)	Collaborative learning (COL) Discussions with diverse others (DDO)
Experiences with faculty (EF)	Student-faculty interaction (SFI) Effective teaching practices (ETP)
Campus environment (CE)	Quality of interactions (QOI) Supportive environment (SPE)

Student responses to each question in the NSSE were coded to relate them to themes and EIs. The coding included assigning a value ranging from 0–60 to each individual question with 0 indicating little or no engagement and 60 indicating maximum engagement. For example, on a question with answer choices "Never, Sometimes, Most of the Time, and Always," Never would be coded as 0, Sometimes as 20, Most of the Time as 40, and Always as 60 [26, 27]. The reasoning behind this coding was to create a scale out of a common number for the questions relating to one EI to be averaged. For each student participant, each response related to an EI was given a score out of 60, and then all responses relating to the same EI were averaged to get an EI score out of 60. EI scores relating to the same theme were then also averaged to get a theme score out of 60.

After average EI scores (10) and average theme scores (4) were calculated for each student participant, the Shapiro-Wilk normality test was completed and Q_Q plots for each variable were also examined to determine if the collected data were in normal or non-normal distribution; or in other words, if a Pearson or Spearman correlation was to be used. Any correlation involving a non-normally distributed variable was completed with a Spearman correlation, rather than a Pearson correlation. This data analysis method is based on recent work by Fang [28].

3. Results

3.1 Normality

Table 2 shows the results from the Shapiro-Wilk normality test. Of the 4 themes and 10 engagement indicators (EIs) tested for normality, 4 EIs, includ-

Table 2. Results from the Shapiro-Wilk normality test

Theme and student GPA	Engagement indicator (EI)	Significance (p-value)
Academic challenge (AC)		0.329
	Higher-order learning (HOL)	0.103
	Reflective and integrative learning (RIL)	0.753
	Learning strategies (LES)	0.024*
	Quantitative reasoning (QUR)	0.090
Learning with peers (LP)		0.135
	Collaborative learning (COL)	0.097
	Discussions with diverse others (DDO)	0.033*
Experiences with faculty (EF)		0.205
	Student-faculty interaction (SFI)	0.002*
	Effective teaching practices (ETP)	0.266
Campus environment (CE)		0.293
	Quality of interactions (QOI)	0.117
	Supportive environment (SPE)	0.014*
Student GPA		<0.001*

* Denotes a non-normal distribution.

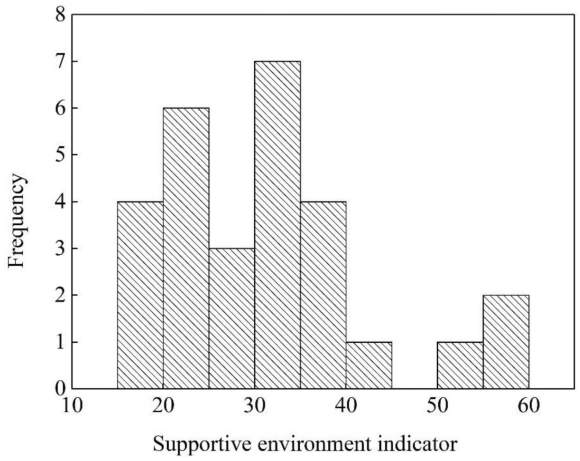

Fig. 3. Distribution of the supportive environment.

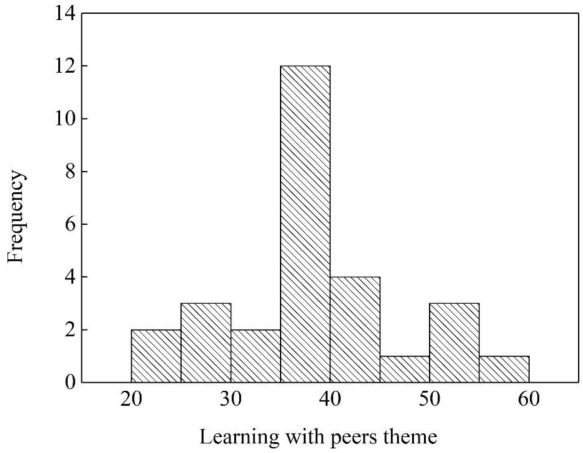

Fig. 4. Distribution of the learning with peers theme.

ing learning strategies, discussions with diverse others, student-faculty interactions, and supportive environment, presented non-normal distributions. All of the remaining EIs and all of the themes presented normal distributions.

Student GPA presented non-normal distributions as well. As two representative examples, Fig. 3 shows the distribution plot of the supportive environment EI, which tested to be non-normal; and Fig. 4 shows the distribution plot of the learning with peers theme, which tested to be normal.

3.2 Students' Engagement Experience

Table 3 shows the mean scores and standard deviations for themes, engagement indicators, and student GPA. A mean score of 60 would indicate maximum levels of engagement in that category. It is important to note that there are specific activities listed in NSSE questions that relate to each theme and EI. These activities are a point of interest in the present study.

As can be seen from Table 3, among the highest levels of engagement for themes were a mean of 37.05 in learning with peers (LP) and a mean of 36.82 in academic challenge (AC). Among the lowest levels of engagement for themes was a mean of 27.55 in experiences with faculty (EF). Among the highest levels of engagement for EIs were a mean of 42.86 in learning strategies (LES) and a mean of 39.11 in discussions with diverse others (DDO). Among the lowest levels of engagement for EIs was a mean of 18.39 in student-faulty interactions (SFI).

3.3 Engagement in Relation to Student GPA

Table 4 shows the correlations between student GPA and themes. Table 5 shows the correlations between student GPA and engagement indicators. Because GPA was non-normally distributed (refer to Table 2), correlations in Tables 4 and 5 are Spearman correlations.

As can be seen from the p-values in Table 4, the correlations between student GPA and themes are not statistically significant. The p-values in Table 5 show that the correlations between student GPA and engagement indicators are not statistically

Table 3. Mean scores and standard deviations for themes, engagement indicators, and student GPA

Theme and student GPA	Engagement indicator	Mean	Standard deviation
AC		36.82	9.17
LP		37.05	8.69
EF		27.55	7.94
CE		34.02	9.98
	HOL	38.93	12.50
	RIL	33.37	10.80
	LES	42.86	12.50
	QUR	32.14	12.70
	COL	35.00	15.81
	DDO	39.11	10.46
	SFI	18.39	14.08
	ETP	36.71	9.86
	QOI	37.86	11.49
	SPE	30.18	11.51
Student GPA		3.60	0.45

Table 4. Spearman correlations between student GPA and themes

	AC	LP	EF	CE
Spearman correlations	0.199	0.038	0.130	0.297
Significance (p-value)	0.311	0.848	0.508	0.125

Table 5. Spearman correlations between student GPA and engagement indicators

	HOL	RIL	LES	QUR	COL	DDO	SFI	ETP	QOI	SPE
Spearman correlations	0.298	0.120	0.133	0.064	0.297	–0.271	0.141	0.006	0.183	0.414
Significance (p-value)	0.123	0.544	0.500	0.747	0.124	0.163	0.475	0.977	0.351	0.029*

* Correlation is significant at the 0.05 level.

significant either, except for the correlation between student GPA and the supportive environment engagement indicator (a moderate Spearman correlation coefficient of 0.41 and p-value < 0.05).

4. Discussion

4.1 Discussion on Students' Engagement Experience

Based on the results described in Section 3, the following paragraphs discuss students' engagement experience in terms of the NSSE themes and engagement indicators.

The learning with peers (LP) theme: This theme includes two engagement indicators: collaborative learning and discussions with diverse others. It focuses on activities that students engage in with other students in order to learn the material in a more effective way. Representative activities include asking or answering other students' questions on the course material, studying for an upcoming exam with other students, or working on projects or assignments with others from a shared course [26, 27]. This kind of collaboration is common in engineering and a standard at most companies that hire engineers. The high level of engagement in activities related to the learning with peers theme (37.05) indicates that FGC engineering students were looking to peers for resources and collaboration academically.

The academic challenge (AC) theme: This theme includes four engagement indicators: higher-order learning, reflective and integrative learning, learning strategies, and quantitative reasoning. It focuses on the learning and reasoning skills students are using in their education. Representative activities relating to this theme include connecting learning to ideas and topics outside of a classroom setting, activating prior knowledge and applying it to a concept, connecting various information sources, and applying numerical information to a concept or idea and analyzing it [26, 27]. Many of these activities are common and necessary in engineering majors, where content from one course may be used in future courses and built upon. The high level of engagement in activities related to the academic challenge theme (36.82) indicates that FGC engineering students were taking active measures to improve their learning and reasoning skills in order to be academically successful.

The experiences with faculty (EF) theme: This theme includes two engagement indicators: student-faculty interaction and effective teaching practices. Representative activities relating to this theme include students feeling that their instructors taught in an organized way, used relevant examples, defined and explained course goals and expectations, and provided feedback throughout the course on different types of assignments [26, 27]. The low level of engagement in activities related to the experiences with faculty theme (27.55) indicates that FGC engineering students did not have strong interaction with faculty or felt apprehensive about interacting with faculty. Mobley et al. [18] reported that FGC engineering students have a sense of independence and a tendency to try to come to solutions on their own.

The learning strategies (LES) engagement indicator: This engagement indicator is related to activities that students complete to help them learn the material presented in their courses. These activities are things like pre-reading assigned chapters before class, taking notes in class and reviewing them after the class period ends, and summarizing what you learned in a class period [26, 27]. Learning strategies are important for students to retain and understand the material they are taught in majors like engineering. The high level of engagement in activities related to the learning strategies engagement indicator (42.86) indicates that students were taking steps to understand the material and be able to succeed academically.

The discussions with diverse others (DDO) engagement indicator: This engagement indicator is related to interactions and discussions with backgrounds differing from one's own. These differences could be in relation to race, ethnicity, economic background, religious beliefs, or political views [26, 27]. Having discussions with people of different backgrounds often opens the door for students to be able to see a situation or problem from a different point of view and gives them a new perspective. Having multiple perspectives on a problem makes it quicker and easier in some cases. The high level of engagement in the discussions with diverse others engagement indicator (39.11) suggests that students were open to hearing others' perspectives and having discussions even if a disagreement is a possibility. Overall, students utilized different learning strategies and interacted with diverse groups of peers to gain different perspectives or worked with peers of different skill sets. Many of those learning activities and peer-to-peer interactions are related to the academically challenging components of an engineering degree.

The student-faulty interactions (SFI) engagement indicator: This engagement indicator is related to activities where students interact and collaborate with faculty or work alongside faculty. Activities for this engagement indicator include having discussions with a faculty member (outside of class) about academic performance, career plans, or coursework. Other activities include working with a faculty member in relation to a committee or student group [26, 27].

The interaction that we expected but did not find from the present study was a high level of engagement with faculty. On the contrary, student responses to the NSSE showed a low level of engagement in the experiences with the faculty theme (27.55) and the student-faulty interactions engagement indicator (18.39). This low level of engagement could be due to FGC engineering students being anxious about initiating these interactions. Another reason for the low mean in this category could be the COVID-19 pandemic where the present study was conducted. During this pandemic time, many institutions and individuals handled interactions virtually, and interaction levels may have decreased accordingly.

4.2 Discussion on Student Engagement in Relation to Student GPA

As described in Section 1.3 of this paper, Mazumder et al. [20] reported a weak correlation between students' academic performance and classroom engagement. The research findings of the present study, described in Sections 3.2 and 3.3, only partially support Mazumder et al.'s [20] findings and go one step deeper by revealing that students' academic performance is statistically significantly correlated to a supportive environment, which affects student engagement both inside and outside the classroom.

The NSSE supportive environment engagement indicator relates to students feeling supported by university staff and their institution as a whole. Activities for this engagement indicator include educational institutions emphasizing the following: proving support for students' academic success, using learning support services like a tutoring or writing center, encouraging contact among students with differing backgrounds, providing students with opportunities and events to be involved socially and providing support for students' well-being and out of class responsibilities [26, 27]. The statistically significant Spearman correlation (0.414, $p < 0.05$) between student GPA and the supportive environment engagement indicator emphasizes the critical importance that institutional support plays in affecting FGC engineering students' academic success.

The support can include activities ranging from institutions having learning support services avail-

able to students all the way to institutions providing students with social opportunities connected to societal issues. Sometimes these supports exist, but students may be unaware of them, or think that they are conditionally available. As members of the greater educational community, we can help support FGC students by highlighting available services and activities and fostering a supportive environment for FGC students to be able to succeed.

5. Limitations of the Present Study

The present study has two limitations. First, the sample size was 28, which was the minimum acceptable sample size based on a power analysis. Prior to conducting the present study, a power analysis was conducted with an acceptable power of 0.8 and an alpha (α) of 0.05 for a two-tailed test. The results showed that the minimum acceptable sample size was 28. The present study would be enhanced if it involved more student participants.

Second, all student participants were from the same university, which is a public research university in the Mountain West region of the U.S. The present study would also be enhanced if it included student participants from other institutions of higher education across the nation, such as private institutions, teaching-focused universities, and community colleges.

6. Conclusions

Most of the research on first-generation college (FGC) students has been focused on FGC students as a whole rather than on a specific discipline. A few studies on FGC students in engineering did not provide an overall big picture specific to the engagement of this category of students. Bridging this research gap, the present study has conducted a quantitative analysis of the engagement of FGC engineering students using the National Survey of Student Engagement (NSSE). The following paragraphs summarize the major research findings made from the present study.

FGC engineering students have shown high levels of engagement in educational activities related to two NSSE themes (learning with peers and academic challenge) and two NSSE engagement indicators (learning strategies and discussions with diverse others). However, FGC engineering students have also shown a low level of engagement in the experiences with the faculty theme and the student-faulty interactions engagement indicator.

There is a statistically significant and moderate correlation (Spearman correlation coefficient of 0.414, $p < 0.05$) between student GPA and the supportive environment engagement indicator. This positive correlation implies that educational institutions should develop a positive environment to support FGC engineering students.

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