Examining Shifts in Sense of Belonging, Engineering Identity, Intent to Persist and Stress Levels: A Repeated Measures Study of First-Generation Students in a First-Year Engineering Program

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Abstract – **This repeated measures study analyzes self-reported variables, including sense of belonging, engineering identity, intent to persist, and stress levels, among first-generation engineering students during their first year of education. Given the persistent stress culture in undergraduate engineering programs, significant efforts are being made to improve these factors to support students' well-being and academic success. Over time, we aim to provide a detailed understanding of how the sense of belonging, engineering identity, intent to persist, and stress interact and evolve to shape the experiences of first-generation students. From the first-year engineering program at a larger Midwestern university, 488 students (27% female, 46% first-generation) responded to our survey twice at the end of their Fall 2023 and Spring 2024 semesters. Independent and paired-sample t-tests were conducted to analyze the significance of any changes in belonging, engineering identity, intent to persist, and stress levels among first-year and continuing engineering students. Results showed a significant decrease ($p < .05$) for both first-generation and continuing-generation engineering students across two variables, i.e., intent to persist (averaged scores decreased) and stress levels (average scores increased), between their Fall 2023 and Spring 2024 end-of-semester survey responses. Sense of belonging and engineering identity remained stable. These results suggest that persistence and stress are more immediately influenced by the academic environment, whereas belonging and identity may evolve more gradually. Targeted support for stress management and persistence is crucial, particularly for first-generation students, to promote well-being and academic success.**

Keywords — first year engineering, sense of belonging, engineering identity, persistence, stress, engineering education

I. Introduction

The one-size-fits-all approach of the current first-year engineering curriculum offers little flexibility, leaving most students with few opportunities to customize their academic path. This rigid structure provides limited opportunities for personalized learning, making it challenging for students to align their coursework with their unique interests and career goals [1]. Such inflexibility may exacerbate feelings of disconnection and hinder academic persistence, particularly for those navigating systemic barriers in their engineering education [2].

Similarly, the subject of this study, first-generation college students (FGCS) [3] who are the first in their immediate families to attend college (with neither parent holding a bachelor's degree) [3], when compared to continuing-generation college students (CGCS), also face lower degree completion rates compared to their peers. In this study, we argue that the rigidity and lack of flexibility in engineering curricula contribute to mental health and well-being (MHW) challenges among first-year students, specifically FGCS, which are manifested in a reduced sense of belonging, weakened engineering identity, lower intent to persist, and heightened stress levels.

Engineering is widely recognized as one of the most stressful fields in higher education [4], [5], with undergraduate students reporting elevated levels of stress [6], [7], anxiety, depression, and PTSD

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compared to their peers [8]. Common contributors include heavy academic workloads [7] - [9], sleep deprivation [6, 9], and exam pressures [10], [11]. Despite perceiving their mental health as worse than that of other undergraduates [12], engineering students are significantly less likely to seek help for mental health challenges [13]. These challenges often extend throughout students' undergraduate education.

II. Research Aim

This study is part of a broader project related to expanding the flexibility of the first-year engineering program through modularization [14]-[18]. *In this paper, we report on the baseline quantitative data collected from participants in the First-Year Engineering (FYE) program during the Fall 2023 and Spring 2024 semesters, which will be collected repeatedly in subsequent semesters*. The data pertain to their perceived sense of belonging, engineering identity, persistence, and stress levels among FGCS and CGCS populations. These baseline data will serve as a comparison point for future data collected after the implementation of our proposed course modularization aimed at revolutionizing our FYE program. The modules we envision will each be 0.5-1 credit and will cover a wide variety of topics appropriate for students in a FYE program. We expect the modules to improve MHW among first-year engineering students within the above constructs by allowing students to tailor their coursework to their interests much earlier in the curriculum. These data comparisons will help assess any changes in the under investigation psychological constructs over time. Additionally, the baseline data will lay the groundwork for future research, particularly the collection of qualitative data through interviews and focus groups involving students, faculty, and advisory staff.

III. Theoretical Framework

This study employs an integrated theoretical framework to examine the distinctive academic experiences of first-generation college students (FGCS) in First-Year Engineering (FYE) programs. Combining social identity theory [19] and Tinto's theory of student retention [20], the framework provides a comprehensive perspective on the challenges faced by FGCS. Tinto's model [20] reveals how individual challenges, such as academic preparation gaps, interpersonal dynamics (including limited peer networks), institutional policies (like rigid curriculum structures, the focus of this study), and broader societal factors (including disparities in cultural capital) collectively shape students' educational trajectories. These interconnected barriers often undermine FGCS's sense of belonging and persistence in engineering disciplines, highlighting the critical need for targeted interventions.

Building on this foundation, social identity theory [19] sheds light on how these students navigate identity formation within the engineering culture, where feelings of marginalization and a lack of representation can create psychological barriers to developing a strong professional identity. The theory highlights how external validation from faculty and peers serves as a critical mechanism for identity development and academic persistence. Complementing these perspectives, Tinto's theory [20] emphasizes how precarious academic integration, often compounded by financial pressures, family obligations, and limited institutional support, directly impacts their retention rates. The theory particularly underscores the importance of early social and academic integration in preventing attrition among vulnerable student populations.

By synthesizing these two theoretical lenses, the study develops a robust framework for understanding the challenges facing first-generation engineering students. Social identity theory [19] helps explain the psychological dimensions of belonging, and Tinto's model [20] connects these factors to persistence outcomes. This integrated approach not only advances theoretical understanding but also informs practical interventions, such as curriculum redesign, that can more effectively support the success of FGCS students in engineering education. The framework ultimately advocates for holistic, multi-pronged strategies that address both institutional barriers and individual needs to create equal opportunities and pathways in STEM education for all.

IV. Methods

Our research design employed a quantitative questionnaire-based approach to address our research questions. We developed the questionnaire for students to report on their engineering identity, intent to persist, sense of belonging, and perceived stress, utilizing several established scales. The Engineering Identity scale, developed by Godwin, measured students' identification with engineering through constructs of recognition, interest, and competence [21]. Students' intent to persist in engineering was assessed using adapted items from the Persistence in Engineering Survey by Mamaril [22], focusing on both academic and professional persistence. To measure students' sense of belonging in the engineering community, the scale developed by Verdín et al. [23] was utilized, linking belongingness to academic and professional outcomes. Lastly, the Perceived Stress Scale (PSS) by Cohen et al. [24] was used to gauge students' perceived stress levels.

After obtaining IRB approval, all students enrolled in the first-year engineering courses were required to complete the survey. Study participants were provided with homework credit for participating in our study, and students who did not wish to have their data used in research could opt out of the study. The survey was administered at the end of their Fall 2023 and Spring 2024 semesters.

Complete responses from 488 consenting students (27% female, 54% first generation) who responded to our surveys at the end of their Fall 2023 and Spring 2024 semesters were used for analysis. Independent sample t-tests were conducted to explore if there were any significant differences among the measured variables between first-generation college students (FGCS) and continuing generation college students (CGCS) during either of the Fall 2023 or Spring 2024 semesters. Then, paired sample t-tests were conducted to analyze the significance of any changes within FGCS and CGCS from Fall 2023 to Spring 2024. We used the Benjamini–Hochberg procedure to adjust our significance threshold ($\alpha = 0.05$) due to the multiple comparisons performed.

V. Results

When FGCS and CGCS were compared within the Fall 2023 (Table 1) and Spring 2024 (Table 2), there were no significant differences in any of the four variables: sense of belonging, engineering identity, intent to persist, and perceived stress.

Table 1

Fall 2023 - Independent-Samples T-Test Results

(N = 488; FGCS =223; CGCS = 265; df = 486)

Variable	FGCS (M ± SD)	CGCS (M ± SD)	p
Overall Sense of Belonging	26.93 ± 6.99	27.30 ± 5.94	.533
Overall Engineering Identity	51.10 ± 9.87	51.35 ± 9.54	.796
Overall Intent to Persist	17.17 ± 2.25	17.29 ± 2.04	.552
Overall Stress	19.57 ± 6.97	18.86 ± 7.25	.277

Note. M = Mean, SD = Standard Deviation. Values marked with an asterisk (*) indicate significance at p<.05 (two-tailed).

Table 2

Spring 2024 - Independent-Samples T-Test Results

(N = 488; FGCS =223; CGCS = 265; df = 486)

Variable	FGCS (M ± SD)	CGCS (M ± SD)	p
Overall Sense of Belonging	26.47 ± 6.85	26.79 ± 5.89	.577
Overall Engineering Identity	50.10 ± 10.62	51.48 ± 8.90	.242
Overall Intent to Persist	16.53 ± 2.91	16.64 ± 2.74	.687
Overall Stress	21.89 ± 5.35	21.69 ± 6.04	.716

Note. M = Mean, SD = Standard Deviation. Values marked with an asterisk (*) indicate significance at p<.05 (two-tailed).

However, as expected, when compared to FGCS, the average scores of CGCS were higher for all variables and lower for stress levels, reflecting the typical trends and differences that have historically existed between the two groups of students in engineering and elsewhere.

As shown in Table 3, the FGCS who responded to both the Fall and Spring surveys did not exhibit any significant changes in their sense of belonging and engineering identity scores; however, they did show significant changes in their intent to persist ($p = .003$) and stress levels ($p < 0.001$).

Table 3

FGCS - Fall 2023 vs Spring 2024 - Paired-Samples T-Test Results

(N = 223; df = 222)

Variable	Fall (M ± SD)	Spring (M ± SD)	p
Overall Sense of Belonging	26.94 ± 7.00	26.47 ± 6.85	.284
Overall Engineering Identity	55.11 ± 9.87	50.45 ± 10.62	.357
Overall Intent to Persist	17.17 ± 2.25	16.54 ± 2.91	.003*
Overall Stress	19.57 ± 6.98	21.89 ± 5.35	.000*

Note. M = Mean, SD = Standard Deviation. Values marked with an asterisk (*) indicate significance at p<.05 (two-tailed).

The CGCS also depicted the same trends with significant change in their intent to persist ($p = .000$) and stress levels ($p < .0001$) scores (Table 4). The intent to persist score average for both groups decreased from Fall 2023 to Spring 2024, while their stress levels increased during the same period.

Table 4

CGCS - Fall 2023 vs Spring 2024 - Paired-Samples T-Test Results (N = 265; df = 264)

Variable	Fall (M ± SD)	Spring (M ± SD)	p
Overall Sense of Belonging	27.30 ± 5.94	26.79 ± 5.89	.148
Overall Engineering Identity	51.34 ± 9.54	51.48 ± 8.91	.796
Overall Intent to Persist	17.29 ± 2.04	16.64 ± 2.74	.000*
Overall Stress	18.86 ± 7.25	21.70 ± 6.04	.000*

Note. M = Mean, SD = Standard Deviation. Values marked with an asterisk (*) indicate significance at p<.05 (two-tailed).

VI. Discussion

In this study, we did not note any significant differences in any of the outcomes. It is noteworthy to mention here that the study participants were repeat respondents who completed our survey at the end of both semesters. Responses from participants who did not complete our survey on both occasions were excluded from the analysis in the present study. However, our previously published work [18], focusing on data from Fall 2023, revealed significant differences ($p < .05$) between the two groups in terms of engineering identity, intent to persist, and stress levels, with FCGS scoring low on both variables while scoring high on stress levels. These differences are likely an artifact of examining one subset of the data to facilitate comparisons between Fall and Spring.

Still, this analysis comparing Fall 2023 and Spring 2024 reveals a concerning trend in the psychological well-being of first-year engineering students. A significant decrease in the intent to persist, coupled with a marked increase in stress levels among both first-generation college students (FGCS) and continuing-generation college students (CGCS), suggests that students face escalating psychological challenges as they progress through their first year of college. This pattern aligns with prior research indicating that academic pressures, social adjustment difficulties, and a demanding curriculum contribute to heightened stress and attrition risks among engineering students [25], [26]. Furthermore, FGCS may experience compounded stress due to limited familial guidance and financial strain, amplifying their vulnerabilities [27]. These findings underscore the need for targeted interventions to support students' mental health and foster resilience throughout their first-year journey in engineering programs.

Our project aims to modularize the first-year engineering program, creating a more inclusive and supportive academic experience. By introducing a flexible course structure, we strive to offer multiple curricular pathways and opportunities for course customization, enabling all of the engineering undergraduates to tailor their education. This approach is designed to foster a welcoming, student-centered environment that promotes both academic success and psychological well-being.

VII. Conclusion

The paired analysis of first-year engineering students from Fall 2023 to Spring 2024 reveals a concerning trend of declining intent to persist and increasing stress levels among both first-generation college students (FGCS) and continuing-generation college students (CGCS). While no significant differences were noted between the groups in this study, earlier findings indicate that FGCS are particularly vulnerable, scoring lower on engineering identity and intent to persist while reporting higher stress levels. These findings highlight the persistent psychological challenges engineering students face, exacerbated by a demanding curriculum, social adjustments, and systemic barriers for FGCS.

Targeted mental health interventions, such as counseling, peer mentoring, and stress management workshops, are crucial in addressing the rising challenges. Tailored resources for first-generation college students (FGCS) – including academic advising, financial planning, and initiatives to foster a sense of belonging – can further support their success. Additionally, implementing a system to monitor students' well-being and academic progress will enable the timely identification of individuals who need support and the delivery of appropriate assistance.

VIII. Aknowledgements

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