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WIP: Exploring First Generation Engineering Technology Students Acquisition of the Engineering Identity- Phase 1

Dr. Gretchen Dietz, Western Carolina University

Gretchen A. Dietz is the Director of the Engineering Discovery Program and an Assistant Professor of Civil Engineering within the College of Engineering and Technology at Western Carolina University. Her research interests include engineering identity development, social capital, wellbeing, K-12 STEM outreach, first year experiences, and qualitative methodologies.

Jordan C Bullington-Miller
Audrey Rorrer

Audrey Rorrer, PhD, is a Research Associate Professor in the Computer Science Department at UNC Charlotte, where she also serves as Assistant Director of the Center for Education Innovation & Research. Dr. Rorrer's scholarship areas include the science of broadening participation in computing, SoBP, which is a recognized domain of critical importance in STEM workforce development and educational programming. Her work has focused on educational programs, outreach and collective impact activities that expand the national pipeline into STEM careers. College student development and Faculty career development are central themes across her body of work.

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Abstract

This paper presents a work in progress (WIP) for an NSF project examining first-generation (FG) engineering technology (ET) students, focusing on their academic performance, development of engineering identity, and utilization of social capital in comparison to continuing generation (CG) peers. This project employs a two-phase mixed methods approach. It will evaluate the academic performance of FG versus CG engineering students while leveraging the theoretical frameworks of engineering identity development [1] and social capital [2] to explore their experiences. The project's aim is to inform the design of a comprehensive program that enhances support for engineering technology students as they navigate their educational journeys, utilize their resources, and cultivate their engineering identity. Additionally, the data collected will provide insights into their development in relation to demographic factors such as first-generation status, race, gender, and age. In this paper, we outline our project and present preliminary findings from our study, which is currently in Phase 1 of quantitative data collection. We highlight data trends regarding engineering identity development and social capital utilization among first-generation and continuing generation engineering technology students.

Introduction

Engineering Technology programs, encompassing both two-year and four-year tracks, have seen significant growth in recent years. According to *Engineering and Engineering Technology by the Numbers* [3], a total of 14,312 degrees were awarded in 2019 alone, with these degrees conferred by 111 institutions offering Engineering Technology programs. Despite the large number of degrees awarded within these disciplines, there is a notable gap in research exploring the experiences of Engineering Technology students.

Similar to those in Engineering Science programs, Engineering Technology graduates are eligible to pursue professional engineering licensures in 35 states. Although licensure procedures may vary by state, graduates of Engineering Technology programs can follow career paths comparable to those of Engineering Science degree holders. Despite the growing prevalence of engineering technology programs and the overlap in career trajectories, little research has been conducted to examine the experiences of engineering technology students. To address this gap, this study focuses on comparing the experiences of first-generation and continuing-generation Engineering Technology students.

With this NSF funded project, we seek to address the following research questions:

1. To what extent do the academic performance metrics of first-generation engineering technology students compare to the performance of continuing-generation peers?

2. How do first-generation engineering technology students conceptualize and consolidate their engineering identity as part of their education as compared to their continuing generation peers?
    a. How do first-generation engineering technology students describe their engineering identity development?
3. How do first-generation engineering technology students understand and leverage forms of capital to persist in their program as compared to their continuing-generation peers?
    a. How do first-generation engineering technology students describe their uses of social capital within their engineering education?

In this WIP paper, we present the findings of some of the quantitative data collected at the current status of the grant. We have pilot data from 136 participants that explore research questions 1 and 2. We have obtained survey results that look at how FG and CGS explore their engineering identity development, as well as the social capital that was leveraged to persist in their programs.

Literature Review

First Generation Engineers

Research on first-generation students (FGS) in higher education has highlighted several challenges they face. These students experience difficulties with academic integration [4], [5], struggle with the rigors of STEM fields [4], encounter feelings of alienation [5], and face higher levels of stress [5] and mental health challenges [5], [6]. Systemic barriers, including struggles with gatekeeping courses early in STEM programs [7], [8], inadequate preparation from high schools for the rigor of college coursework [7], [9], and a disproportionate representation from low-income backgrounds, exacerbate these challenges and hinder their path to persistence and degree completion.

Despite these obstacles, FGS who persist in engineering and STEM fields do so through personal agency [9], motivation [9], self-efficacy [10], [11], and both familial [9], [12], [13] and institutional support [9], [13], [14]. The importance of support networks is evident, as parental support has been shown to predict student engagement, and strong familial relationships contribute to the willingness to seek mentors and other forms of support in college [12]. A sense of belonging is also crucial for persistence. Smith and Lucena [15] found that first-generation and low-income students often experience a lack of belonging in engineering, compounded by awareness of perceived differences from continuing-generation peers. However, these students bring valuable life experiences to the program, and their sense of belonging is enhanced when faculty recognize these strengths [15], [16]. Faculty and peer mentoring, along with first-year communities, also play a positive role in fostering belonging, confidence, and identity development for FGS [14], [16], [17].

Engineering Identity

Engineering identity refers to how an individual recognizes themselves and is recognized by others within the field of engineering. It is a key factor in persistence in engineering education [1], [18], and is developed through one's interest, recognition, and perceived competence in engineering [1], [18]. This concept has been widely studied because of its impact on educational and vocational outcomes [1], [19], [20], [21], [22], [23], [24], [25], [26], [27]. Environmental factors, such as campus culture, play a significant role in the development of an engineering identity [19], [20], [28], [29], [30]. Tonso [20] highlighted how the campus culture and organization of life within engineering programs influence how engineering project teams operate, while Fleming et al. [28] showed that a strong sense of community at minority-serving institutions (MSIs) positively influences engineering identity development, which in turn supports persistence and retention in the field. The mental health of engineering students is a growing concern, as high levels of stress, anxiety, and depression affect many, especially given the intense pressures of the field [31].

For FGS, developing an engineering identity enhances their sense of belonging, which positively influences persistence and effort in the field [32]. When FGS perceive themselves as capable of succeeding in engineering and feel a sense of belonging, they are more likely to persist and continue their efforts in the field [32]. While Verdin et al. [32] explored the relationship between engineering identity, grit, and sense of belonging, their study did not delve into the specific factors that contribute to engineering identity development. To date, there has been no research examining the specific factors that foster engineering identity development among first-generation college students in engineering technology programs.

Social Capital

Outside of engineering, social capital has been widely conceptualized as the networks, relationships, and resources that can potentially advance an individual's opportunities and success (e.g., Bourdieu [33], [34]; Coleman [35]; Lin [36]). In engineering, social capital has been studied across different demographic groups. Skvoretz et al. [37] surveyed 11 engineering programs across the U.S. to assess the social capital of various demographic groups. They found few gender-based differences but noted significant differences across ethno-racial groups, suggesting that social capital may influence students' persistence and retention in varying ways depending on their demographic backgrounds. Martin et al. [2] used Lin's [36] theory to study the experiences of Hispanic women in engineering, identifying school personnel, peer groups, and institutional support systems as important sources of social capital.

For first-generation college students, social capital plays a critical role in navigating engineering education. Martin et al. [13] studied the social capital of FGS and continuing-generation (CG) students using the "Name and Resource Generator" tool and found that while FGS had access to fewer engineering-related resources than CG students, some still had considerable access to social capital. Martin [14] further examined the positive roles that educational personnel,

institutional programs, and mentors play in enhancing the social capital of FGS. Much of the existing research has framed the experiences of FGS in engineering through a deficit model, focusing on barriers and challenges. In contrast, we aim to reframe this perspective by focusing on the assets and capital that FGS bring to their educational experience, as well as how they navigate the structures of engineering education. Martin et al. [13] began challenging the deficit framing of FGS, and we seek to build on this work by exploring how the social capital and identity development of FGS in engineering can lead to success.

This project aims to focus on identity development alongside social capital for engineering technology students, specifically exploring how their engineering identity, social capital, peer interactions, and participation in both major-related and extracurricular activities influence their persistence and success in engineering. By building on the work of Martin et al. [13], [14], [38] [13], [14], [40], we will employ mixed methods to better understand the experiences of FGS in engineering technology and the factors that support their persistence and success in the field.

Methodology

This project employs a two-phase, mixed-methods approach, both centered on current undergraduate students in engineering technology programs. The first phase is ongoing and focuses on collecting quantitative data from students enrolled in various engineering technology programs. A survey was created to assess students' Engineering Identity, Social Capital, and Belonging [39]. For the scope of the work described in the paper, the survey was distributed to students from an engineering technology program at a large public university in the U.S. In the next phase of work, we plan to collect experiences of at least 500 students from different colleges and universities, ensuring a broad and diverse range of responses, thereby enhancing the depth and breadth of the findings.

The quantitative survey aims to explore several aspects of students' experiences. Questions focus on understanding their decision to pursue an engineering technology degree, their future, and their sense of preparedness for the program. The survey also asks students about their confidence in completing the degree and their strategies for managing academic challenges. Additionally, students are asked to assess the quality of their interactions with peers, faculty, and staff within their program. The survey includes three specific questions on Sense of Belonging, asking students to rate their degree of agreement that they f*eel valued by the faculty and staff* in their program, *feel like part of the engineering technology community*, and that *they feel comfortable being themselves* within the program. All questions, except for one optional open-ended social identity question, are quantitative (For the complete survey, please see Authors, 2024).

The design of the survey was influenced by three established instruments with proven reliability and validity. The first, the Engineering Identity Survey [1], assesses three constructs of engineering identity: recognition by others and self, interest in engineering, and self-perceived competence in engineering. Another source of influence was the Name and Resource Generator instrument [13], which explores how first-generation engineering students leverage social capital

compared to their continuing-generation peers. With influences in the sociological sciences, Martin et al. [13], created this instrument specifically to measure social capital among engineering students both prior to and during their studies in engineering. Finally, the Sense of Belonging questions were modeled after those used in the National Survey of Student Engagement (NSSE), a widely administered survey that assesses students' time use and the quality of their experiences in college. These belonging questions, first included in NSSE in 2020, have demonstrated strong reliability and validity will also collect demographic information, including race/ethnicity and sex, using language aligned with the Integrated Postsecondary Education Data System (IPEDS) [40].

To ensure inclusivity, an optional open-ended question will allow students to share additional social identities. We will also ask students whether they are the first in their immediate family to attend college, as this is our definition of "first-generation" for the study. Additional questions will explore whether non-first-generation students have family members who earned a college degree and whether that degree is in engineering.

Data analysis for Phase 1 will involve descriptive statistics for aggregate data, while inferential statistics will be used to explore potential significant differences across race/ethnicity and sex subgroups. We will also analyze whether differences between first- and continuing-generation students are statistically significant. These results will help inform the development of interview protocols for Phase 2.

After completing the survey, students will have the opportunity to provide contact information for entry into a drawing for one of ten $100 Amazon gift cards. This survey will be conducted separately to ensure the anonymity and confidentiality of participants' responses. Chosen at random, ten of these students will be invited to participate in Phase 2 of the study that entails qualitative data collection [39].

Preliminary Results

To better understand the experiences of first-generation engineering technology students compared to their continuing-generation peers, our quantitative analysis examined responses to the Engineering Identity and Belonging survey in four categories: Preparedness, Help Seeking Behaviors/Access to Resources, Sense of Belonging, and Engineer Identity. In each category, we used descriptive statistics to reveal if the responses by first-generation respondents differed from their peers within engineering technology. As gaps emerged, we conducted a series of one-way analysis of variance (ANOVA) tests to determine if the differences were statistically significant. Due to smaller sample sizes, we were unable to disaggregate by first-generation status among Race/Ethnicity and Gender subgroups. Such disaggregated comparisons will be the focus of the national survey administered in a subsequent phase of this research project.

Participants

All told, 136 engineering technology students responded to the Engineering Identity and Belonging survey. Of those, 25% reported they were first-generation in alignment with the definition used in this study of first in family to *attend* college. Among continuing-generation students, the majority (92%) reported that a member of their family had completed a college degree. However, in most cases (79%), no family member had earned a college degree in an engineering field. A majority of the participants reported their Race/Ethnicity as White (56%), with the second highest Race/Ethnicity identity being Hispanic students at 14%, following by African American (8%) and Asian (4%). An overwhelming majority of participants identified as Male (73%).

More than 70% of participants reported they were first-year students, enrolling in their engineering technology program following high school graduation. Nearly half of all participants (46%) reported that a demonstrated high aptitude for math or science previously had influenced their decision to pursue engineering technology. While enrolled in college, 69% of the students surveyed indicated they were also working. In most cases, employment was held on a part-time basis with 40% indicating they worked an average of 10-19 hours per week and another 31% reported their average work week was closer to 20-29 hours.

Preparedness

One measure of preparedness is exposure to the foundational math and science coursework required in engineering technology programs. As such, students were asked to indicate any advanced, honors, or college-level coursework they had completed prior to beginning their degree. While not statistically significant, first-generation engineering technology students were notably less likely to report prior exposure to advanced math coursework. A total of 45% of first-generation respondents indicated they had never taken an advanced Precalculus or Calculus course prior to enrolling in the degree program, a rate that was five percentage points higher than continuing-generation peers. Similarly, 79% of first-generation students indicated they had not completed a course specific to engineering previously. While not statistically significant, this was higher than the percentage of their continuing-generation peers who had also not been previously exposed to engineering courses (72%).

However, first-generation engineering technology students were significantly less likely to have completed advanced Chemistry or Physics coursework prior to enrolling in the program. Survey responses indicated that continuing-generation students were 4 times more likely to have completed both Chemistry and Physics compared to their first-generation peers (see Table 1).

Table 1. Prior Advanced, Honors, and/or College-Level Coursework

	First-Generation	Continuing-Generation	p
Advanced Math			
No Precalculus/Calculus	45%	40%	
Precalculus only	33%	25%	
Precalculus and/or Calculus	21%	25%	>0.05*
Advanced Science			
No Physics/ Chemistry	58%	47%	
Physics only	15%	11%	
Chemistry only	21%	17%	*<0.05***
Physics and Chemistry	6%	25%	
Advanced Major-Specific			
No Engineering	79%	72%	>0.05***

Note. *0.56; ***0.006*; ***0.476

Interestingly, while there was no significant gap between first-/continuing-generation engineering technology students in their initial confidence that they would be successful in the degree program, first-generation students were significantly less likely to indicate "Yes" to the question of whether they felt their previous coursework had prepared them to be successful in the four-year engineering technology degree program (First-generation: 41%; Continuing-Generation: 67%; $p < 0.05$).

Help Seeking Behaviors/Access to Resources

It is well-documented in the literature that success in college requires both access to resources, as well as willingness to utilize those supports [41]. As such, respondents in this study were asked survey questions to highlight the type of resources they felt were accessible to them and to indicate their decision or willingness to take advantage of them. While not statistically significant, a gap exists between first-/ and continuing-generation engineering technology students regarding access to a mentor in the engineering field. Only 39% of first-generation respondents indicated they had an engineering mentor they could go to with questions compared to 47% of their continuing-generation peers.

When asked if individuals both internal and external to the college had helped them to identify academic or career opportunities, both first- and continuing-generation students indicated they had received support in the form or scholarship alerts, references, and information related to graduate school and job opportunities from both peers and college-level faculty and academic advisors with no significant gap between the two.

However, while students indicated awareness of these supports, both groups indicated more willingness to engage the help of their peers when experiencing an academic challenge rather than a faculty member or academic advisor. And yet, we see slightly less self-reported engagement with these college-level supports within first-generation students facing an academic challenge. Additionally, first-generation respondents also reported that they were less likely to reach out to a parent or family member when experiencing a challenge in their coursework. Although, in both cases, the gap between first-/continuing-generation students was not statistically significant.

Table 2. Students Indicate Response to Facing Academic Challenges

	First-Generation	Continuing-Generation	p
Willingness to engage Peer Support			
Form a study group	6%	13%	>0.05*
Talk to other students/friends	45%	37%	
Both of above options	20%	34%	
No Peer Support	18%	16%	
Willingness to engage College Support			
Talk to a faculty member	36%	30%	>0.05**
Talk to my academic advisor	0%	9%	
Both of above options	3%	6%	
No College Support	61%	55%	
Willingness to engage External Support			
Talk to external mentor	15%	4%	>0.05***
Talk to my parent/family member	9%	20%	
Both of above options	0%	6%	
No External Support	76%	69%	

Note. *0.71; **0.358; ***0.238

Sense of Belonging

To assess sense of belonging, the administered survey included modified versions of the three sense of belonging questions developed by the National Survey of Student Engagement (NSSE). These questions have been tested successfully for validity and reliability and are presently administered through the NSSE survey annually to four-year colleges across the country [40].

High numbers of both first- and continuing-generation students indicated that they felt comfortable being themselves in the engineering technology department with no significant difference between the two. Similarly, both groups reported strong agreement that they felt valued by the faculty and staff in their engineering technology major. Finally, respondents indicated high degrees of agreement that they felt like part of the engineering technology community. Like the other belonging questions, no significant gaps exist between first-/ and continuing-generation students.

Engineering Identity

To understand how students conceptualize their identities within the field of engineering, respondents were asked first to rate their degree of agreement with the following statements: "*My parents see me as an engineer*," "*My instructors see me as an engineer,"* and "*My peers see me as an engineer*." The results were surprising insofar as they fit within the larger study. While first-generation students self-reported lower levels of preparedness for the engineering curriculum and a lack of access to mentors in the field when compared to their continuing-generation peers, 79% of the first-generation students strongly agreed or agreed that they were seen as an engineer in the eyes of their peers, a rate that was nearly twenty percentage points higher than the continuing-generation respondents (60%). This gap was marginally significant ($p= 0.05$).

However, that strong agreement did not hold when reflecting on how first-generation students felt they were viewed by their parents and faculty. When asked if their parents saw them as an engineer, 72% of first-generation students indicated agreement, a decline of 7 percentage points from the peer perception question. That percentage dropped further when reflecting on how these students believed their faculty viewed them with only 68% indicating agreement. While the gaps between first- and continuing-generation students were not statistically significant in response to the instructor and parent perceptions of them, it is worth nothing that first-generation respondents felt less confident that their faculty and parents saw them as an engineer.

A second set of questions in this category asked students to reflect on their confidence that they understand engineering concepts and could apply them both inside the engineering classroom and beyond. Here too, the results are interesting within the larger study. While no statistical significance was found, first-generation students were more likely than their peers to report fulfillment in the engineering field. First-generation students also reported stronger confidence that they could succeed when faced with an obstacle. All told, 90% of all first-generation

Table 3. Perception of Others / Perception of Self

	First-Gen	Continuing-Gen	p
	Strongly Agree/Agree		
Perception of Others			
My parents see me as an Engineer	72%	76%	>0.05
My instructors see me as an Engineer	68%	66%	>0.05
My peers see me as an Engineer	79%	60%	*= 0.05*
Self-Perception/Confidence			
I find fulfillment in engineering.	90%	86%	*=0.05*
I am confident I can understand engineering concepts in class.	76%	82%	>0.05
I am confident I can understand engineering concepts outside class.	76%	75%	>0.05
I can overcome setbacks in Engineering	90%	74%	>0.05

Note. There is marginal statistical significance between first- and continuing-generation peers in response to "My peers see me as an Engineer" and "I find fulfillment in engineering".

students surveyed indicated they strongly agreed or agreed that they could overcome obstacles in the field, a rate that was 16 percentage points higher than the continuing-generation respondents. This was a remarkable finding given that, at the same time, only 76% of first-generation students reported that they felt confident they could understand engineering concepts both inside and outside the classroom. In both cases, this rate was either on-par with or slightly below the rate of agreement with continuing generation peers (see Table 3).

Discussion

The data collected through the Engineering Identity and Belonging survey revealed a series of interesting, albeit often not statistically significant, findings. On the one hand, first-generation students self-reported they entered their engineering technology program at a disadvantage having completed less advanced or college-level foundational coursework in math, engineering, and significantly, the sciences. This is similar to findings from Bettencourt et al. [7] that FG students had less pre-college preparation than their CG counterparts in math and science courses. Additionally, first-generation respondents were less likely to report access to a mentor in the field of engineering they could approach with questions. Though Smith and Lucena [15] found

that first generation students can experience a lack of sense of belonging in engineering, our finding suggests differently. Both groups reported a strong sense of belonging within the college and the engineering technology majors. When the survey is administered across the US in the next phase of work, the results may be more aligned with the literature. But while not statistically significant, a compelling story emerges regarding engineer identity.

Most first-generation respondents indicated willingness to approach their peers to form study groups or to discuss academic challenges, certainly more so than were willing to approach their faculty, academic advisors, or families when facing those same challenges. As such, it may not surprise us that these students also believe that it is their peers who are more likely to see them as engineers, rather than the faculty in their programs or their families. This prompts the question of how peer-to-peer support is cultivated, how it influences or potentially impedes the relationship between student and college-level supports (faculty, academic advisors) or the student and external resources (engineering professionals, mentors), and how it contributes to the acquisition of engineer identity. These questions become even more salient when we consider the overwhelming majority of first-generation respondents indicated they found fulfillment in engineering and believed they could overcome future obstacles in the field, similar to findings from Verdin et al. [32]. However, a notably smaller number reported confidence that they could successfully apply the concepts they were learning in the engineering technology major.

These questions will inform Phase 2 of this project as we administer the Engineering Identity and Belonging survey nationally to understand a broader picture of the first-generation engineering technology student experience. It is in this final phase that we also engage our qualitative data collection and analysis to better understand how the experiences of first-generation students within engineering technology programs and the relationships formed within those programs contribute to our students' shifting identities from "engineer major" to "Engineer."

Future Work

The next steps of this project include disseminating our survey to engineering technology schools across the nation (Spring 2025). We aim to get 500 participants in the quantitative survey. As results come in, we will begin to interpret our findings, identify general trends, and explore emerging patterns, while also brainstorming additional areas of interest for further investigation. At this stage, our study will transition into qualitative research (Summer 2025). During this phase, we plan to interview at least 10 participants. In Summer 2025, we will analyze the qualitative data and compare it with the quantitative results. In the final phase of our research (Fall 2025 – Spring 2026), we will focus on preparing publications, presenting at conferences, and planning future research initiatives to continue this work.

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