Student Retention in Engineering: Interacting Factors Across Majors

Dr. Kathleen Bieryla, Carnegie Mellon University

Kathleen Bieryla is an Associate Teaching Professor of Biomedical Engineering at Carnegie Mellon University.

Dr. Shaghayegh Abbasi, University of Portland

Shaghayegh (Sherry) Abbasi received her B.S. in electrical engineering from Sharif University of Technology in Tehran, Iran. She continued her education in the Electrical & Computer Engineering Department of the University of Washington where she received her M.S. in 2007 in the field of self-assembly of electronic devices and earned a Ph.D. in 2011 in electrical and computer engineering with an emphasis in novel metal deposition techniques. Her current research interests are related to repetitive transcranial magnetic stimulation (rTMS), specifically investigating treatment outcomes through a combination of FEM simulation and clinical data analysis. Sherry has worked in industry in the role of a senior system design engineer at Lumedyne Technologies, where she developed a software model for a time-based MEMS accelerometer. She then gained significant academic experience through six years of teaching as an adjunct professor at the University of San Diego. Sherry has been collaborating on a bioengineering research project with the Jacobs School of Engineering at UC San Diego since 2016. In addition to technical research, she conducts engineering education research related to project based learning. Sherry aims to apply her knowledge and experience towards creating a dynamic learning environment for students, utilizing a variety of active learning techniques in her classroom and laboratories.

Dr. Jordyn Wolfand, University of Portland

Jordyn M. Wolfand earned a B.S. degree in environmental engineering from Tufts University and an M.S. and Ph.D. degree in environmental engineering from Stanford University. She joined the faculty at University of Portland in 2020 and her research interests are in water resources engineering and urban hydrology.

Student Retention in Engineering: Interacting Factors Across Majors

Introduction

Student retention in engineering programs across the United States has become increasingly challenging in recent years. Roughly 50% of the engineering students fail to complete their studies [1]. The attrition rates are particularly high in regional universities, underscoring the need for strategies and interventions to improve retention rates.

Previous studies [2], [3], [4], [5], [6] show that while high school GPA and mathematics preparation are strong predictors of retention, demographics such as gender and ethnicity have inconsistent effects across universities [2]. Non-cognitive and affective factors such as confidence, interest in engineering, and test anxiety have also been found to be strong predictors of retention [3], [4]. A study across multiple institutes on the impact of engineering identity on retention found a significant difference in the engineering identity scores of students who stayed in engineering through the end of their fourth year of college and those who did not [6].

The focus of this work is to investigate the connection between factors that impact student major selection, engineering identity, demographics, and first-year retention. The goal is to utilize the results as a guideline for creating interventions in first-year engineering courses and experiences that will improve retention rates. The demographics information allows for a focus on populations that are more heavily impacted by attrition in engineering. The results have the potential to contribute to creating a path for widely improving retention in engineering programs.

Methods

The study was conducted at a regional private university in the Pacific Northwest. Students are admitted to the School of Engineering either into a specific major (civil engineering, computer science, electrical engineering, environmental engineering, or mechanical engineering) or as undeclared within engineering. Admission requirements are identical across all engineering and computer science majors. A student survey was created for students in the first-year course titled *Introduction to Engineering (EGR 110)*. EGR 110 is required for all engineering majors, including those who are undeclared in the School of Engineering. The course introduces students to the engineering and computer science majors offered at the university through hands-on laboratory activities and culminates in a team-based design project in which students design and build a tabletop wind turbine. The study was approved by the university's IRB, and consent was obtained from all participants.

The survey was administered to 126 students across 5 sections in Fall 2023, and to 95 students across 4 sections in Fall 2024. The surveys asked students how certain they were in choosing their major, what factors contributed to them choosing their specific major (Table 1), and questions about their engineering identity (Table 2), using Godwin's framework for engineering identity [7]. Major certainty was rated on a 5-point Likert scale (1 = not certain at all to 5 = extremely certain). For questions related to the importance of influencing factors, each factor was rated independently on a 5-point Likert scale (1 = not at all important, 5 = extremely important); students did not rank factors relative to one another but evaluated each separately. Questions on engineering identity were rated on a 7-point Likert scale (0 = strongly disagree, 6 =

strongly agree). In addition, students self-reported demographic information, including gender, race, and first-generation college student status.

Surveys were administered at the end of the introduction to engineering course and filled out anonymously with a random number assigned to each student to allow for within-subject comparisons.

Retention data from the first to the second year was obtained from university administration and matched with the survey data. Erroneous responses (such as random ID numbers that didn't exist in the initial database), incomplete responses, and duplicates were removed from the dataset. The final dataset consisted of 166 students, approximately a 75.1% response rate.

Table 1. Students rated on a 5-point Likert scale how important each factor was in choosing the engineering (electrical, mechanical, civil, computer science) or non-engineering major they are currently in (or will be in, if they were currently undeclared), with 1 = not at all important and 5 = extremely important.

1. Personal interest
2. Abilities/talents
3. Job opportunities after graduation
4. Salary levels
5. Opportunity to serve the society
6. Desired work/life balance
7. Role models in family/friends in the same major
8. What my family want me to study
9. What I have been told to study (by teachers, etc.)
10. How difficult I think the major will be

Table 2. Survey questions related to engineering identity. The prompt for all the questions in this section is: To what extent do you agree or disagree with the following statements? The answer choice was a 7-point Likert scale from Strongly Disagree (0) to Strongly Agree (6) [7].

Construct	Statement
Recognition	My parents see me as an engineer.
	My instructors see me as an engineer.
	My peers see me as an engineer.
Interest	I am interested in learning more about engineering.
	I enjoy learning engineering.
	I find fulfillment in doing engineering.
Performance	I am confident that I can understand engineering in class.
	I am confident that I can understand engineering outside of class.
	I can do well on exams in engineering.
	I understand concepts I have studied in engineering.
	Others ask me for help in this subject.

Statistical Analysis

A Wilcoxon rank-sum test was used to compare major certainty, factor importance, and identity metrics between students who remained in engineering and those who left engineering. Group differences (stayed in engineering, left engineering) were further examined by student demographic characteristics (male/female, first generation/non-first generation, and race, which was coded as white/non-white due to sample size limitations for other categories). Engineering identity statements were both analyzed individually and as grouped constructs: recognition, interest, and performance (Table 2). The analysis was conducted in JMP 18.2.2 (JMP Statistical Discovery LLC, Cary, NC), with significance set at $p<0.05$.

Results and Discussion

Data Summary

Of the completed survey responses, approximately 59.6% identified as male, 29.5% as female, and the remainder (10.8%) as other/non-binary/preferred not to say. At the survey point, there were 42 civil engineers, 41 computer science majors, 15 electrical engineers, 63 mechanical engineers, 3 environmental engineers, and 2 undeclared engineering majors. Only 2 students changed majors within engineering (not including those that started as undeclared), and by the beginning of their second year, there were 36 civil engineers, 35 computer science majors, 13 electrical engineers, 57 mechanical engineers, and 4 environmental engineers.

Approximately 30% (50/166) of students self-identified as first-generation college students, and 52.4% (87/166) as non-white. Approximately 12.6% of students (21/166) left their engineering major between the first and the second year, corresponding to an 87.4% retention rate, and the majority of these (71%; 15/21) left the university entirely. It should be noted that this study only examines retention from the first to the second year, and students may have left engineering or the university after their second year of enrollment.

The population of the university and survey population is unique in that most students are non-white, and nearly 1/3 of the students are first-generation college students. While not included in the formal analysis, 84.9% lived on campus during their first year for the fall 2024 cohort, while the rest commuted. This question was not asked in fall 2023.

Differences in Factors

Students who left engineering had lower certainty of their major at the end of the first semester (Figure 1, $p = 0.044$). All other factors for choosing a major did not significantly differ between students who stayed and students who left engineering. Although not statistically significant, students who left engineering reported a higher level of choosing engineering because they were told to do so (Figure 1). In addition, students who left engineering were less likely to report having role models in engineering compared to those who stayed in engineering indicated by a lower median score, though not statistically significant (Figure 1).

These results show that students who are retained versus those who leave engineering may approach selecting their engineering major similarly, with primary reasons being their interest in the major, job opportunities available, and salary levels (Table 3). However, unsurprisingly, students who leave engineering are less certain about their major overall and may have been influenced or pressured by others to choose an engineering major initially.

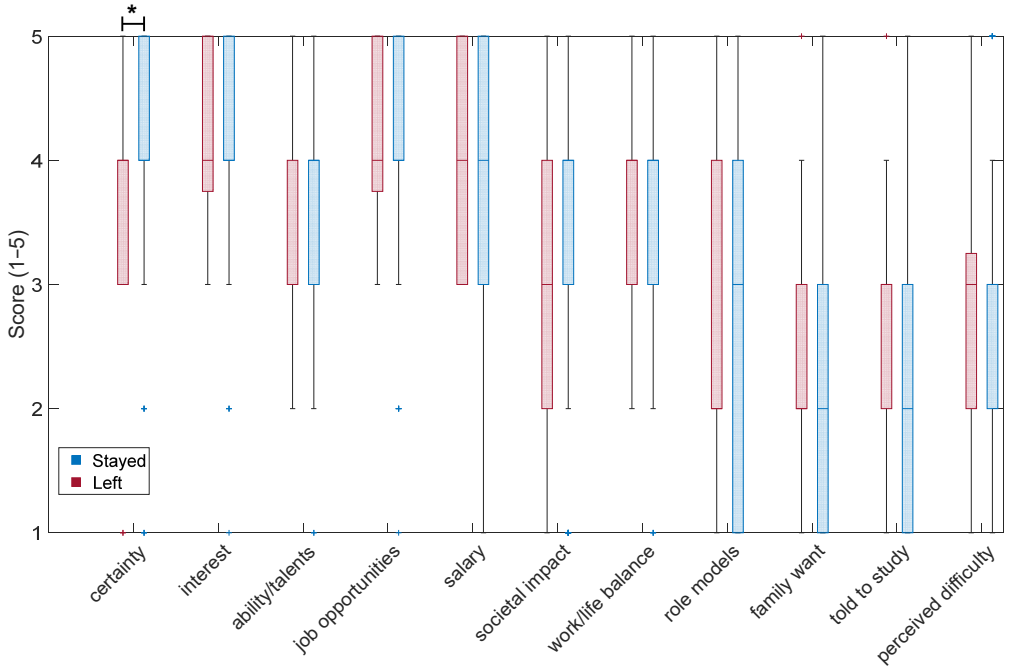

Figure 1: Box plots for student responses to the question of major certainty and factors affecting major choice. Students who left engineering (n = 21) are in red, while students who stayed in engineering (n = 145) are in blue. The box represents the interquartile range (IQR), with the inside line representing the median. The whiskers extend to 1.5 x IQR, and outliers are represented as plus signs. The asterisk denotes a statistically significant difference ($p < 0.05$).

Table 3: Mean ± standard deviation for students who left engineering and students who stayed in engineering for major certainty and factors affecting major choice.

		Left	Stayed
Major certainty		3.6 ± 1.1	4.0 ± 0.9
Factor	Personal interest	4.0 ± 0.7	4.2 ± 0.8
	Abilities/talents	3.5 ± 0.9	3.8 ± 0.9
	Job opportunities after graduation	4.1 ± 0.8	4.2 ± 0.8
	Salary levels	4.0 ± 0.9	4.0 ± 0.9
	Opportunity to serve society	3.1 ± 1.2	3.5 ± 1.2
	Desired work/life balance	3.5 ± 0.9	3.7 ± 0.9
	Role models in family/friends in the same major	2.6 ± 1.4	2.6 ± 1.4
	What my family wants me to study	2.5 ± 1.1	2.2 ± 1.1
	What I have been told to study (by teachers, etc.)	2.6 ± 1.0	2.1 ± 1.1
	How difficult I think the major will be	2.8 ± 1.1	2.7 ± 1.1

Engineering Identity

Examining engineering identity, students who left engineering rated lower on the following questions compared to students who remained in engineering: I am interested in learning more about engineering ($p=0.007$); I enjoy learning engineering ($p=0.017$); I find fulfillment in doing engineering ($p=0.012$); I understand concepts I have studied in engineering ($p=0.005$) (Figure 2, Table 4). When grouping the statements for the constructs of recognition, interest, and performance, interest was significantly lower for students who left engineering compared to those who remained ($p=0.009$) (Figure 3). While overall identity was not significantly different between the two groups ($p=0.065$), those who left engineering were lower (4.1 (1.3), median (IQR)) compared to those who remained in engineering (4.6 (1.2)).

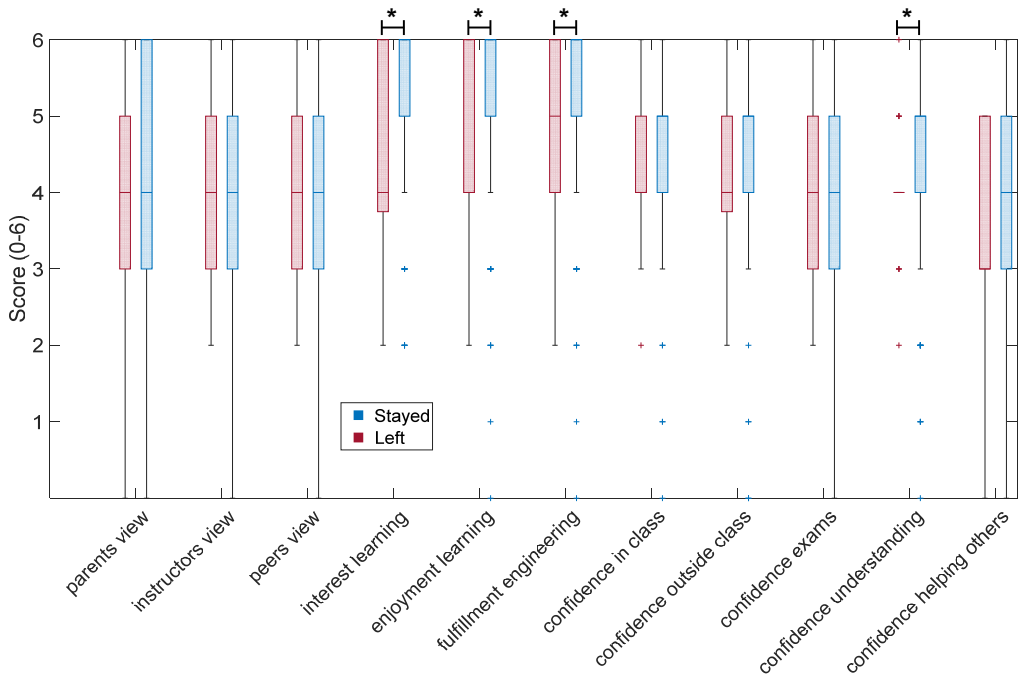

Figure 2: Box plots for student responses to the question about engineering identity. Students who left engineering (n = 21) are in red, while students who stayed in engineering (n = 145) are in blue. The box represents the interquartile range (IQR), with the inside line representing the median. The whiskers extend to 1.5 x IQR, and outliers are represented as plus signs. The asterisk denotes a statistically significant difference (p <0.05).

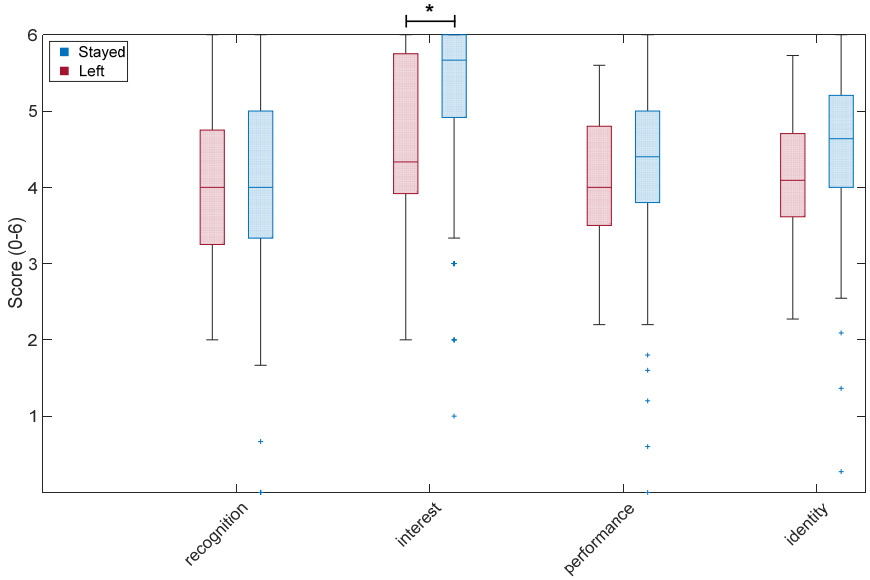

Figure 3: Box plots for engineering identity constructs, which were calculated as the average for questions related to each construct. Students who left engineering (n = 21) are in red, while students who stayed in engineering (n = 145) are in blue. The box represents the interquartile range (IQR), with the inside line representing the median. The whiskers extend to 1.5 x IQR, and outliers are represented as plus signs. The asterisk denotes a statistically significant difference (p <0.05).

Table 4: Mean ± standard deviation for students who left engineering and students who stayed in engineering for engineering identity statements and constructs.

	Left	Stayed
My parents see me as an engineer.	3.9 ± 1.1	3.8 ± 1.2
My instructors see me as an engineer.	4.0 ± 0.9	3.7 ± 1.2
My peers see me as an engineer.	3.9 ± 1.5	4.3 ± 1.5
Recognition	**4.0 ± 1.1**	**4.0 ± 1.3**
I am interested in learning more about engineering.	4.1 ± 1.2	4.0 ± 1.5
I enjoy learning engineering.	4.0 ± 1.1	4.1 ± 1.3
I find fulfillment in doing engineering.	4.4 ± 1.4	5.2 ± 1.1
Interest	**4.5 ± 1.2**	**5.2 ± 1.2**
I am confident that I can understand engineering in class.	4.5 ± 1.3	5.2 ± 1.2
I am confident that I can understand engineering outside of class.	4.5 ± 1.2	5.2 ± 1.0
I can do well on exams in engineering.	4.3 ± 1.1	4.7 ± 1.1
I understand concepts I have studied in engineering.	4.2 ± 1.1	4.6 ± 1.2
Others ask me for help in this subject.	4.1 ± 1.2	4.1 ± 1.3
Performance	**4.0 ± 0.8**	**4.6 ± 1.2**
Identity	**3.4 ± 1.3**	**3.7 ± 1.6**

Our results indicate that overall engineering identity is linked with retention, and other studies have shown similar results [5], [6], [8]. Across these studies, the findings consistently show that stronger engineering identity, expressed through belonging, recognition, and perceived competence, is positively associated with student persistence and retention in engineering programs. Our results indicate that students' interest is strongly related to retention, but also that students who leave engineering have less confidence in understanding concepts they've learned in classes. This is corroborated by anecdotal evidence from counselors and advisors that students struggle academically with math and chemistry courses in their first semester.

Demographic results

Retention rates did not differ between genders; other studies show that gender differences are unique to each institution [9], [10]. There was no statistically significant difference in engineering retention between white and non-white students ($p=0.052$), though non-white students made up 71.4% of the students who left engineering. Overall, 17.2% of non-white students who started in engineering left engineering, compared to 7.3% of white students. While there was no statistically significant difference in retention between first-generation students and non-first-generation students ($p=0.060$), 20% of first-generation students did not stay in engineering, compared to 9.3% of non-first-generation students. These results indicate that, while not statistically significant, both race and first-generation status are potential markers of retention in engineering, as expected and found by numerous other studies [11], [12].

Strategies for Intervention

Our findings suggest that student interest in engineering is a primary indicator of retention in engineering from the first to the second year. While not surprising, this provides helpful data to

support added interventions to increase retention at this and other universities. First-year courses could specifically focus on increasing student interest in engineering. Many studies have examined ways to increase student interest. The studies consistently find that student interest in engineering is a dynamic construct that often declines over time unless it is actively supported through engaging, relevant educational experiences. Potential mechanisms include connecting engineering to student lives and specific interests, sparking curiosity, and employing interactive and hands-on learning [13], [14], [15], [16]. The course already employs active learning techniques to complete labs and a culminating final wind turbine project. However, we recognize this project may not appeal to or interest all students. In future years, the project could be adapted for groups with specific interests, or we could incorporate mini-projects throughout the semester that are major- or interest-specific. Another idea would be to poll students at the beginning of the semester to include their specific topics of interest in the course assignments and projects.

Students who left engineering in this study reported less confidence in understanding engineering concepts in their classes. To improve student understanding, especially in classes that are required for engineers but not in the engineering discipline (e.g., math, chemistry, physics, etc.), we suggest working closely with these departments to provide student support as needed (e.g., office hours, flexible grading policies, study groups, etc.). In addition, we suggest the utilization of peer assistants or peer tutors, both in and outside the classroom, to facilitate conceptual understanding.

While not statistically significant, there were marked differences in demographics between those who left engineering and those who stayed. Those who left were more likely to be non-white and the first in their family to attend college. We suggest increasing support for students from these specific demographics. Previous studies have found interventions such as early, structured academic support (e.g., summer bridge programs) and mentoring models to normalize challenges for first-generation students are beneficial [11], [12]. In addition, psychological interventions such as value affirmation and inclusive classroom practices improve retention for minority students [12], [17].

To connect engineering education with some of the motivators for choosing the major (job opportunities and post-graduation salaries), we suggest partnering with engineering industry professionals as well as alumni. Alumni from various majors and with diverse backgrounds could provide guest lectures, be included in networking events, or provide facility tours for the first-year engineering students. This allows students to have more certainty about their major selection and can also help them make connections with possible role models. Hearing about the real-world application of engineering from someone who is working in the field may also solidify the interest area of students' engineering identity, which was significantly different between students who stayed in engineering and those who didn't.

Limitations and Future Work

Our study was limited by the relatively small number of students who left engineering in their second year (21/166). This 87.4% retention rate is relatively high, though it suffered from the selection bias of those who took the survey. Of all the students in engineering for these two cohorts (including those who did not take the survey), the retention rate was 81.7%. This is in line with the average of 82.21 % for first-year retention in engineering (not including computer science) at other universities, according to the recent comprehensive study by Marzouk [18]. Analysis of demographic data was also limited by small sample sizes; for example, non-white students were grouped, although it does not solely include groups traditionally defined as underrepresented in engineering (e.g., Asian identifying students).

In addition, the results are limited to a small, predominantly undergraduate school. Class sizes are limited to 30 students in the introduction to engineering course, whereas many other institutions may have larger cohorts, larger class sizes, and major-specific introduction to engineering courses.

Conclusion

This work investigated the connection between factors that impact major selection, engineering identity, demographics, and student retention in engineering through student surveys. Regarding factors that impact major selection, students who left engineering had significantly lower levels of certainty about their major compared to students who stayed in engineering. In addition, though not statistically significant, students who left engineering reported higher levels of choosing engineering because they were told to do so, possibly pointing to a lack of internal motivation and interest. Students who left also reported lower levels (not statistically significant) on access to engineering role models.

With respect to engineering identity, the survey questions were grouped into three categories: recognition, interest, and performance. Students who stayed in engineering showed statistically significantly higher levels of interest, but there were no significant differences in the areas of recognition and performance. The overall score for engineering identity was also higher for students who stayed, but the difference was not statistically significant. While demographic differences between students who stayed in engineering and those who left were not statistically significant, a higher percentage of non-white students left engineering compared to white students. In addition, the percentage of first-generation students who left engineering exceeded that of non-first-generation students.

Based on our findings, we suggest targeted interventions to improve major certainty and engineering identity in the first year. These include, but are not limited to, building interest in engineering through course content updates, providing resources to increase confidence in understanding and applying material, and resources and community-building programs for first-generation and non-white students.

References

[1] B. Chen and I. Modry-Caron, "Engineering Student Early Dropout Prediction in Regional Universities Using Multimodal AI Student Retention Forecast in Regional Universities," in *ASEE Annual Conference and Exposition*, Montreal, Jun. 2025.

[2] G. Zhang, T. Anderson, M. Ohland, R. Carter, and B. Thorndyke, "Identifying Factors Influencing Engineering Student Graduation and Retention: A Longitudinal and Cross-Institutional Study," *Journal of Engineering Education*, vol. 93, no. 4, Jan. 2004.

[3] C. P. Veenstra, E. L. Dey, and G. D. Herrin, "A Model for Freshman engineering retention," *Adv. Eng. Educ.*, vol. 1, no. 3, 2009.

[4] C. R. Bego, J. Immekus, and J. L. Hieb, "Predictors of First-Year Retention among Undergraduate Engineering Students Who Earned a C in their First-Semester Mathematics Course," in *ASEE's Virtual Conference*, Jun. 2020.

[5] M. Yatchmeneff and M. Calhoun, "Exploring Engineering Identity in a Common Introduction to Engineering Course to Improve Retention," in *ASEE Annual Conference and Exposition*, 2017.

[6] B. E. Hughes, W. J. Schell IV PE, B. P. Tallman, R. Beigel, E. Annand, and M. Kwapisz, "Do I Think I'm an Engineer? Understanding the Impact of Engineering Iden-tity on Retention," in *ASEE Annual Conference and Exposition*, 2019.

[7] A. Godwin, "The Development of a Measure of Engineering Identity," in *ASEE Annual Conference and Exposition*, New Orleans, Jun. 2016.

[8] D. A. Major, K. Reynoldson, X. Hu, S. Burleson, and K. Shryock, "Preliminary Validity Evidence for a Brief Measure of Engineering Identity Preliminary Validity Evidence for a Brief Measure of Engineering Identity Background and Objective," in *ASEE Annual Conference and Exhibition*, Salt Lake City, 2018.

[9] R. M. Felder, G. N. Felder, M. Mauney, C. E. Hamrin, and E. J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. III. Gender Differences in Student Performance and Attitudes," *Journal of Engineering Education*, vol. 84, no. 2, pp. 151–163, 1995, doi: 10.1002/j.2168-9830.1995.tb00162.x.

[10] A. Blasick, C. Valle, and J. Leonard II, "Retention Analysis of Women Engineering Students," in *ASEE Annual Conference and Exposition*, 2012.

[11] S. D. Carver *et al.*, "Operation STEM: increasing success and improving retention among mathematically underprepared students in STEM," *Journal of STEM Education*, vol. 18, no. 3, Jul. 2017.

[12] J. M. Paz, M. Cousins, C. Wilson, and M. Markey, "Retention of First-Year Undergraduate Engineering Students: Role of Psychosocial Interventions Targeting First-Generation College Students," in *ASEE Annual Conference and Exposition*, Seattle, Jun. 2015.

[13] M. J. Terrón-López, M. J. García-García, P. J. Velasco-Quintana, J. Ocampo, M. R. Vigil Montaño, and M. C. Gaya-López, "Implementation of a project-based engineering school: increasing student motivation and relevant learning," *European Journal of Engineering Education*, vol. 42, no. 6, pp. 618–631, Nov. 2017, doi: 10.1080/03043797.2016.1209462.

[14] N. Honken, "Activities that Help Students Maintain and Develop Interest in Engineering During the First Year of College: A Collaborative Sharing and Brainstorming Activity," in *FYEE Conference*, Glassboro, 2018.

[15] E. Alpay, A. L. Ahearn, R. H. Graham, and A. M. J. Bull, "Student enthusiasm for engineering: Charting changes in student aspirations and motivation," *European Journal of Engineering Education*, vol. 33, no. 5–6, pp. 573–585, 2008, doi: 10.1080/03043790802585454.

[16] S. Selcen Guzey, T. J. Moore, and G. Morse, "Student Interest in Engineering Design-Based Science," *Sch. Sci. Math.*, vol. 116, no. 8, pp. 411–419, Dec. 2016, doi: 10.1111/ssm.12198.

[17] S. E. Martin and B. Littlepage, "Identification of Factors Affecting the Retention of Underrepresented Minorities in Engineering," in *ASEE Southeastern Section Conference*, 2018.

[18] O. A. Marzouk, "Benchmarking retention, progression, and graduation rates in undergraduate higher education across different time windows," *Cogent Education*, vol. 12, no. 1, 2025, doi: 10.1080/2331186X.2025.2498170.