2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #52112

Understanding Low-income Engineering Students' Backgrounds, Expectations, and Readiness for Strategic National Workforce Needs

Dr. Manuel A. Jimenez, University of Puerto Rico, Mayaguez Campus

Dr. Jimenez is a professor at the Electrical and Computer Engineering Department in the University of Puerto Rico Mayagüez (UPRM). He earned his B.S from Universidad Autonoma de Santo Domingo, Dominican Republic in 1986, M.S. from Univ. of Puerto Rico in 1992, and Ph.D. from Michigan State University in 1999. His current teaching and research interests include rapid systems prototyping, electronics characterization, and engineering education. He is a senior IEEE and honorary Golden Key member.

Dr. Carla Lopez Del Puerto, University of Puerto Rico, Mayaguez Campus

Dr. Carla Lopez del Puerto is a professor in the Civil Engineering Department at the University of Puerto Rico Mayaguez (UPRM).

Jesus Antonio Sanchez-Perez, University of Puerto Rico, Mayaguez Campus
Dr. Nayda G. Santiago P.E., University of Puerto Rico, Mayaguez Campus

Nayda G. Santiago is professor at the Electrical and Computer Engineering department, University of Puerto Rico, Mayaguez Campus (UPRM) where she teaches the Capstone Course in Computer Engineering. She received an BS in EE from the University of PR, Maya

Daniel Rodriguez Roman, University of Puerto Rico, Mayaguez Campus

S-STEM: Understanding Low-income Engineering Students' Backgrounds, Expectations, and Readiness for Strategic National Workforce Needs

Abstract

Engineering talent is essential for advancing national priorities in artificial intelligence, cybersecurity, microelectronics, and infrastructure resiliency, yet projected workforce shortages, magnified by barriers faced by low-income students pose a significant challenge. The ACCESS S-STEM project seeks to address this gap by reducing financial, academic, and experiential constraints that hamper degree completion among talented, low-income engineering students. To support equitable scholar selection, this study examines applicants' background experiences, expectations, and readiness to contribute to areas of local and national strategic need. Results show strong alignment between prior experiences, declared interests, and long-term goals; findings that highlight experience-based, equity-driven recruitment as promising strategies for expanding strategic engineering workforce pathways.

Introduction

Higher education plays a central role in preparing future professionals to face complex societal challenges and advance local and national priorities[1]. Within this context, electrical, computer, and civil engineers are critical to maintain innovation, competitiveness, and strategic resilience in fields such as artificial intelligence, microelectronics, cybersecurity, and infrastructure systems[2,3,4,5]. Despite strong projected growth in these areas, recent U.S. Bureau of Labor Statistics and the National Center for Education Statistics forecasts show a widening gap between workforce demand and the supply of qualified graduates, with a shortfall expected to exceed 33% by 2033[6,7,8].

Addressing this shortage takes particular significance when we look at the segment of low-income students, who usually face systemic barriers to persist and complete their degrees despite representing a substantial portion of the potential STEM workforce[7,8]. This S-STEM project, short-named ACCESS (Advancing Civil, Computer, and Electrical engineering Scholars for Success), addresses these disparities through a scholarship-based model that integrates formative academic support, experiential learning, and socio-cognitive strategies to improve persistence and graduation rates of academically talented students with demonstrated financial need. The project aims to strengthen pathways into professional practice and graduate study in areas aligned with local and national strategic needs (LNSN).

This paper examines the background experiences, expectations, and readiness of ACCESS scholarship applicants. It focuses on their academic trajectories, engagement in professional development, extracurricular and leadership involvement, and long-term career goals to identify early indicators of potential alignment with LNSN fields.

Preliminary results of applicant data point to strong alignment with important LNSN areas, based

on descriptive metrics and formal statistics gathered during the recruitment process. The rest of this paper provides in the next section an outline of the ACCESS project and its academic context; followed by a review of literature in career and major selection and the factors influencing specialization and electives. Section IV presents the research questions, participants' profiles, and analysis methods. The final sections discuss findings in relation to national workforce needs and concluding remarks.

Project Goals, Structure, and Setting

ACCESS integrates an evidence-based scholarship model that combines formative interventions, experiential learning, and socio-cognitive strategies to improve persistence and graduation rates among talented students with financial need. The project targets Electrical, Computer, and Civil Engineering students who have completed their third academic year and who denote potential to contribute to LNSN areas. It delivers a sequence of longitudinal interventions planned to impact at least 39 students across three cohorts, emphasizing three key strategies: (1) strengthening sense of belonging to support persistence, (2) enhancing self-efficacy and professional competencies through structured formative activities, and (3) promoting workforce readiness in LNSN areas via experiential learning opportunities. Partnerships with industry and research labs enable access to internships, networking, and research opportunities, creating pathways to post-graduation employment or graduate programs aligned with LNSN areas.

The project is being implemented at the University of Puerto Rico Mayagüez (UPRM), a land-grant - space-grant institution recognized for producing high-caliber engineers for the local and national workforce[9]. For the 2025-26 academic year, UPRM enrollment reached 10,889 students, of whom 5,213 (47.9%) were in the College of Engineering[10]. The 2025 graduating class produced 653 new engineers. However, systemic changes in the UPR system have increasingly affected students from low-income families, many of whom offset rising educational costs by taking external jobs, often slowing their academic progress. Institutional indicators show significant drops between first-year retention and later years persistence, particularly in senior-year continuation and graduation rates. In critical disciplines such as electrical, computer, and civil engineering, the last five years have witnessed drops of up to 25% persistence into the senior year, and 18% in graduation. Considering that $\approx 80.8\%$ of Puerto Rican high-school students come from low-income families[11], these trends put at risk the UPRM traditional talent contribution levels to the local and national workforce.

Within this context, identifying factors during the scholars' recruitment process that predict alignment with LNSN workforce and graduate education pathways is essential for maximizing the long-term impact of ACCESS.

Prior Art

A number of theoretical models that include concepts such as motivation, identity, cognition, and context serve as the foundation for research on career and major selection in higher education. Social Cognitive Career Theory (SCCT) provides a dominant framework for explaining how self-efficacy, outcome expectations, and contextual supports shape students' academic interests and career-related choice goals[12,13]. Expectancy–Value Theory highlights how expectations for success and subjective task values—including interest, utility, and perceived cost—influence early academic

choices[14]. Self-Determination Theory emphasizes autonomy, competence, and relatedness as foundational psychological needs supporting motivated persistence[15]. Career selection is seen as a process of becoming shaped by recognition and belonging within disciplinary groups, according to identity-based theories, such as STEM and engineering identity frameworks[16,17,18]. Sociological perspectives emphasize how perceived job alternatives are either limited or made possible by social capital and structural access[19]. According to research, a college student's choice of specialization and electives is influenced by a number of factors, including degree requirements, course structure, instructor qualities, career relevance, and personal development[20]. While career alignment is in line with SCCT result expectancies[13], factors like skill development and curriculum breadth indicate expectancy–value attitudes connected to interest and attainment value[14]. Persistence within specialization areas is additionally influenced by instructor characteristics that shape students' disciplinary identity and sense of belonging, as well as by structural constraints that function as contextual barriers or supports[18]. Despite all these variants, our search for early predictors of post-graduation professional paths has gone dry.

Methods

This study examines whether engineering students' background experiences, including professional development activities, academic performance (GPA and credit completion), commitments, and other formative indicators, can help predict their professional choices, long-term goals, and potentially affect their readiness to contribute as future professionals to areas of LNSN. Using a mixed-methods approach, the analysis draws from institutional records and student-reported data to explore structural and individual factors shaping engineering career choices, goals, and readiness. Beyond informing scholars' selection, these data address three research questions:

- RQ1: How do professional development experiences influence engineering students' interest in areas of LNSN?
- RQ2: What role do professional development experiences and extracurricular engagements play in shaping long-term career goals within strategic engineering sectors?
- RQ3: To what extent do financial constraints and time availability affect students' readiness to pursue careers in LNSN fields?

Data collection occurred in two phases. Phase I pre-screened applicants in the target disciplines who had completed their 3rd year of the 5-year engineering curriculum and who demonstrated financial need. A total of 172 applicants completed this phase. Phase II used a ten-item instrument (see Table 1) to assess students' interest, experiences, and goals in LNSN areas. Students also submitted academic transcripts and resumes. This phase yielded 85 complete responses, which combined with academic performance indicators formed the primary analysis dataset.

The cohort comprised 29 Computer (34%), 28 Electrical (33%), and 28 Civil Engineering students (33%), spanning years 4–8: 32 (38%) in fourth year, 29 (34%) in fifth, 22 (26%) in sixth, and 2 (2.4%) in seventh or beyond. GPAs ranged from 2.1–3.9 (M = 3.17, SD = 0.40), credit approval rates from 35.6% - 118.9% (M = 85.6%, SD = 14.3%), and estimated terms to graduation from 1 - 7 (M = 3.9, SD = 2.5). Nineteen students (22.3%) reported working 5–20^{+} hr/wk. These data reflect ample variation in academic progression and time availability.

Table 1: Questionnaire used in Phase II.

No.	Question	Type
Q1	Identify one or more areas of LNSN that align with your academic interests.	Closed: Multi-item list
Q2	Why are you interested in the selected areas?	Open (50-120 words)
Q3	Describe any relevant experiences you've had in such areas.	Open (50-120 words)
Q4	Explain the impact of such experiences on your development.	Open (50-120 words)
Q5	Discuss your long-term goals.	Open (50-120 words)
Q6	Provide a numbered list of extra-curricular experiences you have participated to date.	Open
Q7	Do you currently hold a job?	Closed: Yes/No
Q8	Please, indicate the number of hours you dedicate to your current job.	Closed: Scale 1 – 20^{+}
Q9	Provide an evidence of the number of weekly working hours.	File Upload
Q10	What is your anticipated graduation date?	Closed: Date 3-yr frame

Analysis Process

RQ1 examined whether students' selections of LNSN areas in Q1 were influenced by their prior professional development and extracurricular experiences reported in Q3 and Q6. Fifteen focus areas identified by local and federal agencies were included in Q1: Artificial Intelligence, Communications Systems, Microelectronics and Semiconductor Manufacturing, Energy Systems, Spectrum Management, Internet of Things, Power Systems Resilience, Digital Signal Processing, Coastal and Flood Risk Management, Infrastructure Resilience, Water Resources, Structural Engineering, Transportation Systems, and Disaster Recovery.

Two matrices were constructed: X, listing reported prior experiences, and Y, capturing selected interest areas. Although responses expanded the list of LNSN areas to 33 through an "Other" option, the regression analysis focused on the 15 areas with sufficient representation. An elastic-net logistic regression (ENLR) model was used for the analysis. The ENLR achieved a median ROC–AUC of approximately 0.79, with 10 of 15 areas above 0.75, indicating that students' experiences meaningfully predicted their stated interests. A 300-run permutation test on the Y labels confirmed that the observed predictive performance significantly exceeded random expectations ($p = 0.0033$), reinforcing the non-random relationship between prior experiences and area choice.

RQ2 explored how professional development experiences (Q3) and extracurricular involvement (Q6) aligned with long-term career goals as described in Q5. An elastic-net ordinal cumulative-logit model was used to predict goal categories from experience categories, optimizing the Ranked Probability Score (RPS). The model achieved a mean $RPS \approx 0.20$, $MAE \approx 0.35$, and within-1 accuracy of ≈ 0.88, indicating a strong ordinal predictive alignment. A 200-run permutation test yielded significance at $p = 0.01$, demonstrating that students' experience profiles provided meaningful structure for predicting their articulated career goals.

RQ3 assessed whether students' financial and time constraints, captured via weekly work hours, affected their readiness to pursue careers in NSN sectors. Two measures were constructed: a work-burden indicator (*WB*) based on *Work Hours*, and an NSN Career Readiness index (*NCR*). The *NCR* combined three normalized components: academic performance (50%), area alignment (35%), and long-term goals (15%), yielding a 0–100 score. Academic readiness incorporated GPA, credit completion, and expected time to graduation; alignment reflected program–area relevance, declared interests, and professional development experiences; long-term goals used scores derived

from RQ1 and RQ2 analyses. Each student's highest-scoring area served as readiness score.

To test the effect of work commitments, students were grouped into groups $G1$ (Work Hours = 0) and $G2$ (Work Hours > 0). Group means were nearly identical ($G1 : 79.15$, $SD = 10.76$, $n = 66$; $G2 : 78.96$, $SD = 10.89$, $n = 19$). A linear regression of *NCR* on *WB* produced a non-significant coefficient of -0.62 ($SE = 0.72$, $p = 0.389$, $R^2 = 0.009$). A binary model produced a similarly negligible working effect (-0.19, $SE = 2.81$, $p = 0.945$, $R^2 \approx 0.0001$). These results provide no statistically significant evidence that work hours in this cohort influence readiness levels. Given $G2$'s small size ($n = 19$), a larger cohort may yield a clearer pattern.

Results and Discussion

Consistent with the project's goal of strengthening pathways into LNSN workforce areas, results show clear alignment between students' interests, background experiences, and long-term aspirations. The most frequently selected interest areas—Infrastructure Resiliency (62%), Structural Engineering (55%), Power and Energy Systems (48%), Disaster Recovery (41%), and AI (35%)—closely matched their reported experiences in Construction, Structural Engineering, Energy Systems, and Transportation. ENLR analyses confirmed that prior professional development and extracurricular participation strongly predicted interest in LNSN fields (median ROC–AUC≈ 0.79; 10 of 15 areas ≥ 0.75), while ordinal models demonstrated similar predictive strength for long-term goals (within-1 accuracy ≈ 0.88). In contrast, work burdens showed no significant effect on readiness. These findings underscore that early experiential engagement—not employment constraints—most reliably signals alignment with LNSN pathways, offering actionable guidance for ACCESS's equity-minded recruitment strategy.

Conclusion

This study provides evidence that early professional development and extracurricular engagement play a decisive role in shaping engineering students' alignment with areas of local and national strategic need. The strong predictive links observed between prior experiences, stated interests, and long-term goals reinforce the importance of integrating experience-based indicators into future ACCESS recruitment cycles. These factors provide early identifiers for students whose academic trajectories and motivations position them to contribute to resilience, sustainability, and critical infrastructure; areas where national shortages persist. Although work burdens did not significantly affect readiness in this cohort, continued monitoring remains important given financial pressures faced by low-income students. Overall, the findings support an equity-minded recruitment approach that leverages formative experiences to select scholars most likely to persist, graduate, and transition into high-impact engineering pathways.

Acknowledgment

This research was supported by the National Science Foundation (NSF) under Award S-STEM DUE 2526845. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.

References

[1] World Economic Forum, "Technological advancements and human development: A tale of two worlds." Online, 2025. Last retrieved on 2025-07-12.

[2] U.S. Department of Defense, "National defense science and technology strategy." Online, 2023. Last retrieved on 2025-05-14.

[3] National Institute of Standards and Technology, "American compete act – final report," tech. rep., NIST, 2023. Last retrieved on 2025-06-22.

[4] N. T. Carter, "U.S. army corps of engineers civil works: FAQs on organization and efficiency reviews," tech. rep., USACE, 2025. Last retrieved on 2025-08-22.

[5] American Society of Civil Engineers, "2021 report card for America's infrastructure." Online, 2021. Last retrieved on 2025-07-03.

[6] U.S. Bureau of Labor Statistics, "Occupational outlook handbook: Architecture and engineering occupations." Online, 2024. Last retrieved on 2025-07-03.

[7] U.S. Bureau of Labor Statistics, "Industry and occupational employment projections overview and highlights, 2023–33," *Monthly Labor Review*, 2024. Accessed 2025-02-17.

[8] A. Kodey, J. Bedard, J. Nipper, N. Post, S. Lovett, and A. Negreros, "The US needs more engineers. What's the solution?." Online, 2023. Last retrieved on 2025-08-22.

[9] American Society for Engineering Education, "Profiles of engineering and engineering technology, 2022," tech. rep., American Society for Engineering Education, Washington, DC, 2023. Last retrieved on 01/08/2024.

[10] OPIMI, "UPRM dashboards." Online, 2025. Last retrieved on 02/20/2025.

[11] Puerto Rico Department of Education, "Perfil del departamento de educación," tech. rep., Puerto Rico Department of Education, February 2024. In Spanish. Last retrieved on 02/04/2024.

[12] R. W. Lent, S. D. Brown, and G. Hackett, "Toward a unifying social cognitive theory of career and academic interest, choice, and performance," *Journal of Vocational Behavior*, vol. 45, no. 1, pp. 79–122, 1994.

[13] R. W. Lent, S. D. Brown, and G. Hackett, "Contextual supports and barriers to career choice: A social cognitive analysis," *Journal of Counseling Psychology*, vol. 47, no. 1, pp. 36–49, 2000.

[14] J. S. Eccles and A. Wigfield, "Motivational beliefs, values, and goals," *Annual Review of Psychology*, vol. 53, no. 1, pp. 109–132, 2002.

[15] R. M. Ryan and E. L. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," *American Psychologist*, vol. 55, no. 1, pp. 68–78, 2000.

[16] H. Markus and P. Nurius, "Possible selves," *American Psychologist*, vol. 41, no. 9, pp. 954–969, 1986.

[17] H. B. Carlone and A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *Journal of Research in Science Teaching*, vol. 44, no. 8, pp. 1187–1218, 2007.

[18] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice," *Journal of Engineering Education*, vol. 105, no. 2, pp. 312–340, 2016.

[19] P. Bourdieu, "The forms of capital," in *Handbook of Theory and Research for the Sociology of Education* (J. G. Richardson, ed.), pp. 241–258, Greenwood Press, 1986.

[20] J. J. Miller *et al.*, "Determinants of intra-major specialization and career decisions among undergraduate biomedical engineering students," *Journal of Engineering Education*, 2024.