

Tailoring Interventions for Developing Engineering Talent in Areas of National Strategic Need

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Abstract - National priorities in artificial intelligence, cybersecurity, microelectronics, infrastructure resiliency, and water resources management have intensified workforce demand in electrical, computer, and civil engineering, yet U.S. degree production continues to fall short of these needs. This work-in-progress examines how lightweight application data can be leveraged to design targeted interventions that support upper-level engineering students' degree completion while aligning them with areas of National Strategic Need (NSN). Using data from 85 applicants to a senior-level scholarship program, a streamlined profiling scheme was designed, grounded in academic momentum and NSN interest. A group of eighteen scholars were selected, with diverse academic momentum and clear NSN orientation. Analysis of applicant characteristics revealed distinct patterns across majors and NSN clusters, enabling the design of differentiated supports and momentum- responsive advising. Findings demonstrate the utility of a minimal, yet strategically chosen data set for guiding intervention planning and refining future recruitment cycles, offering a practical approach for strengthening the NSN-focused engineering talent pipeline.

Index Terms – Engineering workforce development, National strategic need areas, targeted interventions in engineering, STEM talent pipeline enhancement.

INTRODUCTION

The demand for engineers in areas of national strategic need (NSN), such as artificial intelligence, cybersecurity, advanced manufacturing, sustainable energy systems, and resilient civil infrastructure continues to grow more rapidly than universities can supply new graduates [1–4]. Workforce forecasts consistently point to critical shortfalls in electrical, computer, and civil engineering, fields that underpin national technological capacity and infrastructure resilience [5–7]. At Hispanic-serving institutions, this rising demand intersects with persistent constraints such as limited student financial resources, uneven access to experiential learning opportunities, and extended time-to-degree patterns. Together, these conditions pose significant challenges to cultivating an equitable and adequately prepared engineering talent pipeline aligned with NSN priorities [8, 9].

Targeted financial and academic support initiatives for students close to degree completion offer one strategy for addressing these challenges. Programs that combine

economic assistance with structured academic and professional development have been shown to improve persistence, reduce financial strain, and enhance engagement with priority career pathways [10, 11].

This study is situated within one such initiative: The National Science Foundation–funded project “*An S-STEM Model to Enhance Engineering Workforce Development in Areas of Local and National Strategic Need through Financial, Academic, and Professional Supports for Talented, Low-Income Students*”. Shortened ACCESS (Advancing Civil, Computer, and Electrical engineering Scholars for Success), this project integrates elements of a structured theory-of-change model with principles of differentiated instruction to support engineering undergraduates and promote engagement with NSN-aligned technical fields [12, 13].

This paper presents an analysis of application data from ACCESS's first of three scheduled recruitment cycles. Using a minimalistic set of descriptors collected during recruitment, the analysis examines how student characteristics—specifically academic momentum and NSN interest alignment—can guide the development of tailored interventions and inform future recruitment and selection strategies. The study is guided by the following questions:

- What do ACCESS applicant characteristics reveal about upper-level engineering students interested in NSN pathways?
- How can lightweight variables be used to construct meaningful student profiles?
- How might these profiles inform targeted intervention design and strengthen future recruitment cycles?

The remainder of this paper presents the theoretical model guiding the profiling approach; describes the institutional setting, applicant population, and resulting profiles; outlines the intervention strategies deployed for funded scholars; and concludes with recommendations for future recruitment and program development.

THEORETICAL MODEL

This study draws on ACCESS' theory-of-change perspective by viewing student progression toward NSN-aligned careers as an outcome of intentional, evidence-based supports that reinforce academic momentum, self-efficacy, and professional identity. Within this framework, even a minimal recruitment data set can serve as an early, actionable indicator

of students' readiness for targeted interventions that influence outcomes in persistence and degree completion [10], [11].

The study also draws on principles of differentiated instruction, which postulate that aligning learning experiences with students' readiness levels, motivations, and interest profiles enhances engagement and deepens commitment to aspirational pathways [12], [13].

By integrating these complementary perspectives, this study positions recruitment-stage data as a strategic entry point for constructing actionable student profiles that enable tailoring of academic advising, experiential placements, and mentoring structures, allowing ACCESS to deliver developmentally appropriate, NSN-responsive interventions strengthening degree progression and workforce readiness.

ACADEMIC SETTING, POPULATION, AND DATASET

I. Academic Setting

The University of Puerto Rico–Mayagüez (UPRM) is a land-grant and space-grant institution recognized for supplying well qualified engineers to the local and national workforce [14]. In the 2024–25 academic year, the total campus enrollment reached 10,616 students, with nearly half of them (46.9%) enrolled in the College of Engineering. That year, 689 new engineering degrees were awarded [15]. Despite this strong output, academic indicators in civil, electrical, and computer engineering programs, which are five-year-long at UPRM, reveal notable gaps between senior year persistence and graduation. Given that 80.8% of Puerto Rico's high-school students come from low-income households [16], these trends threaten UPRM's long-standing capacity to contribute trained engineers to the labor market.

II. Target Population

ACCESS targets fourth-, fifth-, and sixth-year students who have demonstrated academic talent, verified economic need, and are pursuing degrees in civil, electrical or computer engineering. While financial need is institutionally established for all applicants, the project operationalizes academic talent through indicators of academic momentum—cumulative GPA, credit completion, and year-of-study status—that reflect sustained academic progress and readiness for targeted NSN-aligned supports. Eligibility requirements included a minimum GPA of 2.5/4.0 and 70% of credit approval for their current study year.

III. Dataset Structure and Characteristics

The dataset in this study included 85 applications received during the program's first recruitment cycle. Applicants completed a short instrument designed to verify eligibility and provide early signals of readiness for differentiated interventions. In alignment with the project's minimal-data profiling strategy, the dataset included: degree program, year of study, GPA, credit-completion percentage, and self-reported areas of NSN interest. These variables offered a lightweight yet strategically informative portrait of students' academic trajectories and emerging professional orientations.

A binary indicator identifying those students selected as scholars was appended to enable comparisons between selected and non-selected applicants.

Descriptive patterns within the dataset reveal notable variation in academic momentum and NSN interests across majors and stages of study. As shown in Tables I and II, applicant GPAs ranged from 2.33 to 3.97 ($M = 3.19$, $SD = 0.38$), with Computer Engineering students exhibiting the highest mean GPA (3.32) and Electrical Engineering students showing the narrowest GPA range.

TABLE I
DISTRIBUTION OF ACCESS APPLICANTS BY STUDY PROGRAM

Study Program	Applicants n, (%)	GPA: min–max (mean, SD)	Study year: min–max (mean, SD)	Credit %: min–max (mean, SD)
Civil		2.33 – 3.89	4 th – 8 th	48.9–118.9
Engineering Computer	39, (46%)	(3.10, 0.40)	(4.87, 0.95)	(86.8, 13.7)
Engineering Electrical	22, (26%)	2.30 – 3.97	4 th – 6 th	50.3–101.0
Engineering		(3.32, 0.41)	(5.18, 0.80)	(80.5, 12.6)
		2.57 – 3.87	4 th – 7 th	35.6–110.0
Engineering	24, (28%)	(3.22, 0.31)	(4.83, 0.87)	(88.3, 15.8)
		2.33–3.97	4 th – 8 th	35.6 – 118.9
Overall	85, (100%)	(3.19, 0.38)	(4.94, 0.89)	(85.6, 14.3)

TABLE II
DISTRIBUTION OF ACCESS APPLICANTS BY STUDY YEAR

Study Year	Applicants n, (%)	GPA: min–max (mean, SD)	Study program mix (n)	Credit %: min–max (mean, SD)
		2.33 – 3.89	CvE: 17;	48.9 – 118.9
Fourth	32, (46%)	(3.10, 0.40)	CpE: 5; EE: 10	(89.1, 15.3)
		2.30–3.97	CvE: 12;	35.6 – 105.3
Fifth	29, (26%)	(3.32, 0.41)	CpE: 8; EE: 9	(85.4, 15.3)
		2.57–3.87	CvE: 9;	50.3 – 93.3
Sixth	22, (28%)	(3.22, 0.31)	CpE: 9; EE: 4	(80.6, 10.5)
		2.80 – 3.01		85.5 – 88.7
Higher	2, (2.4%)	(2.90, 0.15)	CvE: 1; EE: 1	(87.1, 2.3)
		2.33–3.97	CvE: 39;	35.6 – 118.9
Overall	85, (100%)	(3.19, 0.38)	CpE: 22; EE: 24	(85.6, 14.3)

Credit completion ranged from 35.6% to 118.9% ($M = 85.6\%$, $SD = 14.3$), with Electrical Engineering applicants demonstrating the highest average progress (88.3%) but also the greatest variability. Civil Engineering displayed the widest spread in study maturity (4th–8th year) alongside mid-range credit progress (86.8%). When viewed by year, credit completion declined from Year 4 (89.1%) to Year 6 (80.6%), while variability narrowed, suggesting increasing convergence in academic standing as students approach graduation. Year 5 exhibited the broadest GPA range, and Year 6's population was dominated by Civil and Computer Engineering students.

NSN interests were diverse and spanned multiple high-priority technical areas. The most frequently selected clusters included Infrastructure Resiliency ($n = 37$), Power Systems ($n = 31$), Structural Engineering ($n = 31$), Artificial Intelligence ($n = 24$) and Transportation Systems ($n = 24$). These patterns indicate both, a broad resonance of NSN domains across the applicant pool and a meaningful variation in academic momentum.

PROFILE DEVELOPMENT AND RESULTS

The ACCESS profiling scheme used two analytical dimensions: *Academic Momentum* and *NSN Interest*. Academic Momentum operationalized the academic talent criteria, reflecting cumulative GPA and credit-completion percentage, while NSN Interest captured the coherence between students' stated interests and the technical domains embedded in their major. Together, these dimensions offered a lightweight yet robust framework for understanding how upper-level students differ in their preparation and orientation toward NSN fields.

Academic momentum was categorized as *High* ($\geq 90\%$ of credits and GPA ≥ 3.5), *Moderate* (80–90% of credits and GPA 3.0–3.5), or *Low* ($< 80\%$ of credits or GPA < 3.0). Applicants with either GPA < 2.5 or approval $< 70\%$ were not eligible (DNQ). At the same time, NSN Interest Alignment was classified as *Clear* when interests aligned naturally with disciplinary preparation, *Exploratory* when students listed multiple or diffuse NSN areas, and *Misaligned* when interests fell largely outside the student's major. Combining these two dimensions yields nine potential profiles, each illustrating distinct advising and intervention needs.

An analysis of all applications revealed that 95.3% of responses were distributed in profiles across the entire academic momentum spectrum with overly Clear alignment. The largest groups corresponded to academically steady students whose interests matched their fields of study. These students typically require structured pathways such as capstone placements, internships, or targeted research experiences, to translate their readiness into progression toward NSN fields. Low-momentum applicants showed clear or exploratory alignments and represent candidates that would require proactive advising, workload calibration, and scaffolded experiences designed to rebuild academic trajectory while maintaining engagement in NSN topics. Exploratory profiles appeared only among Low-momentum students who fell in the DNQ band. None of the students exhibited Misaligned interests, suggesting broad resonance of NSN domains among applicants. Table III lists the profile distribution of students.

TABLE III

PROFILE DISTRIBUTION FOR APPLICANTS AND SCHOLARS

Academic Momentum	Clear Alignment Applicants	Clear Alignment Scholars	Exploratory Applicants
High	12 (14.1%)	7 (38.9%)	0 (0.0%)
Moderate	33 (38.8%)	8 (44.4%)	0 (0.0%)
Low	36 (42.4%)	3 (16.7%)	4 (4.7%)

The scholars' group, 18 in total, contained a balanced blend of academic momentum categories as can be observed in Table III. All had Clear-alignment profiles. The largest proportion (44.4%) were moderate momentum students, followed in number by the high-momentum group (38.9%), denoting ACCESS' emphasis on supporting upper-level students with readiness and coherent engagement with NSN fields. The selection of a modest proportion of

Low-momentum, Clear-alignment profiles (16.7%), denotes the weight within the project to students with coherent NSN interests despite requiring structured support to accelerate completion.

These profiles form ACCESS' basis for a differentiated intervention plan, enabling a tailored approach to academic coaching, mentoring, and experiential NSN engagements.

TAILORED INTERVENTION PLAN

The ACCESS intervention plan translates the profiling framework into tiered supports that reinforce academic momentum, strengthen professional identity, and deepen engagement with NSN-aligned pathways. To maintain coherence and scalability across recruitment cycles, activities are organized into three shared, term-based streams that allow differentiated participation within a unified cohort model.

The first stream consists of professional-formation workshops, invited talks, and NSN-focused seminars offered several times per term. All scholars participate together, but reflective tasks vary by momentum level. High-momentum scholars complete career-mapping activities that connect session themes to post-graduation plans. Moderate-momentum scholars apply workshop insights to academic planning and course sequencing. Low-momentum scholars engage in structured reflections that reinforce persistence, clarify short-term goals, and link NSN topics to immediate academic recovery. Peer mentors facilitate these reflections to support individualized processing.

The second stream comprises a unified experiential-learning pipeline. High-momentum scholars are encouraged to pursue NSN-aligned research roles, internships, or co-ops. Moderate-momentum scholars also participate in co-ops, internships, or mentored design challenges that balance professional development with academic stability. Low-momentum scholars receive coaching to rebuild academic trajectory and engage in modular research tasks or scoped special projects compatible with recovery-friendly course loads. Across all profiles, experiential opportunities emphasize authentic NSN engagement without risking overextension.

The third stream provides socio-cognitive supports through faculty mentoring, peer mentoring, and iterative Individual Development Plans (IDPs). Interaction intensity scales with momentum level, ranging from career refinement for high-momentum scholars to proactive advising, regular check-ins, and structured community-building for moderate- and low-momentum scholars.

A culminating end-of-term event recognizes scholars' progress, affirms capability, and strengthens belonging within the ACCESS community.

LESSONS LEARNED AND RECOMMENDATIONS

The analysis of data obtained from the first ACCESS recruitment cycle yielded several insights highlighting how lightweight data can guide selection and intervention design.

First, academic momentum, operationalized through GPA and credit completion, proved highly informative for

identifying readiness across the full range of profiles. Scholars were selected from the entire academic momentum spectrum, demonstrating the relevance of supporting both academically advanced students ready for deep NSN engagement as well as those requiring structured momentum-building supports. The prevalence of low-momentum, clear-alignment scholars reinforced the value of combining talent indicators with professional-orientation data, rather than relying solely on GPA and progress.

Second, NSN Interest emerged as a strong discriminator in the selection and intervention readiness. Clear alignment dominated the applicant pool, and all scholars fell within this profile, indicating that coherent NSN orientation at entry is central for rapid placement into experiential activities and effective tailoring of supports across momentum levels.

Third, descriptive patterns across majors and maturity levels revealed structural differences in academic progress. Different disciplines exhibited different proportions of momentum-classified applicants, underscoring the need for major-responsive interventions that address uneven preparedness as students approach graduation.

Looking ahead, future recruitment cycles would benefit from adding a small number of items capturing NSN clarity, motivation, and contextual constraints. Integrating validated measures of self-efficacy or career confidence could strengthen momentum-alignment assessments and improve mentoring assignments. Finally, formalizing a profile-based intervention guide will ensure consistent application of differentiated supports across cohorts as ACCESS scales.

CONCLUSION

This study demonstrates that even a small, simple dataset can yield meaningful insight into upper-level engineering students' readiness for pathways in areas of National Strategic Need. Developing actionable profiles enables scholarship programs to tailor interventions that strengthen academic momentum and NSN career alignment. Early evidence suggests that this profiling approach enhances customized advising and experiential placement. Future cycles will refine data collection and expand evaluation measures to further reinforce NSN-focused workforce development.

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