WIP: Engineering Persistence: A Support System for Students in Financial Need to Succeed

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***Abstract*—Engineering graduates have significant opportunities for meaningful careers and social mobility, yet there needs to be more support for financially disadvantaged, academically gifted students. To improve these circumstances, we have introduced the Engineering Persistence project, an NSF-funded S-STEM scholarship program, at Rowan University. This project provides a group of students, selected by financial need and academic talent, with scholarships up to 10,000 USD per year, depending on financial need. In addition to these scholarships, we integrated a support system that includes interventions to support first-year engineering students' social and professional growth in their degree plans. We include in this paper the data collection and analysis process for the first year of this project, including the administration of the pre-survey, and the exploratory factor analysis conducted on the resulting data. This work in progress research paper aims to validate an instrument to assess the impact of an integrated support system on students' persistence in Rowan's engineering students.**

I. Introduction

Engineering graduates have significant opportunities to embark on fulfilling careers and attain social mobility. However, there is a deficiency in adequate support for economically disadvantaged, yet academically gifted students. To remedy this, we are implementing an intervention system that provides financial assistance to academically talented students, establishes a support network to cultivate cooperative learning with peers, and promotes inclusivity and a mindset centered on diversity, equity, and inclusion. By supporting students both financially through the scholarship and socially through the support network interventions, we hope to allow these undergraduates to focus on school without as many outside pressures. This paper outlines the data collection and analysis procedures to determine the effectiveness of these interventions and the validity of the instrument used to measure them. The initial analysis sets the baseline to assess the intervention's impact and to validate the instrument. Evaluating the impact of the interventions will be part of the future work.

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II. Background

There is a need across the U.S. to improve the college experience for engineering students who are under-represented/ under-served (UR/US). Reflecting on the ongoing lack of diversity in the science and engineering fields, the NRC 2011 report underscores the untapped potential of UR/US individuals in these areas, stating that they currently represent an underutilized asset and a missed opportunity to meet the nation's technological demands [1]. Likewise, the National Academies emphasize that promoting diversity in STEM is crucial at the national level to attract and retain the most talented individuals to STEM professions [2]. Despite successful efforts to boost the retention of engineering students through the Engineering Learning Community (ELC) established with previous S-STEM funding, Rowan University College of Engineering (CoE) confronts diversity challenges akin to those observed nationwide. Black and Hispanic students, women, LGBTQ+ students, first-generation college students, and transfer students are underrepresented in the CoE compared to other colleges across campus. Furthermore, a 2016 baseline climate survey at the same university revealed that these groups generally exhibit lower participation in engineering-related activities, encounter less inclusivity in classrooms and overall educational experiences, face more instances of discrimination in academic settings, and perceive a less inclusive overall climate [3].

With this in mind, we are testing two major interventions to aid low-income students with academic promise, and promote a more inclusive learning environment for all. We use a conceptual model that adapts Tinto's student integration model, which recommends institutional actions to promote students' persistence. This model argues that the most important factor in increasing success, retention, and, therefore, graduation is the students' motivation to persist in their careers and degree program. The first intervention is to improve the ELC. In the past, the ELC has consisted of students sharing specific sections of first-year engineering and core courses together, often living in the same dorms if they choose to live on campus, and attending a series of seminars hosted by their assigned mentor. We have recently added DEI-focused seminars within the ELC to improve students' knowledge of DEI principles and their skills in creating an inclusive campus community.

The second major intervention is the S-STEM Scholarship program. Incoming students who have completed the FAFSA application, and been identified as in financial need were invited to apply for the S-STEM Scholarship, which offers up to 10,000 USD per year for four years. Students who receive the S-STEM Scholarship are part of the ELC and reap the same benefits of living with and taking the same class sections as their fellow scholarship recipients.

Scholarship students will also have the opportunity to participate in the Diversity Catalyst Leadership Program (DCLP), which promotes leadership skills development. The DCLP is broken up into 3 certificate programs: Bronze, Silver, and Gold. Each level of this certificate program offers different goals for students to pursue throughout their college experience (typically one certificate across a semester, or a full academic year), which will bolster their career skills before graduation.

These interventions aim to shape students into advocates and allies for DEI principles, which they can carry forward during their academic career and into their professional careers. Employers have expressed that familiarity with and exposure to diverse cultures are desirable yet often deficient qualities in STEM graduates [4]. In addition, employers have identified leadership prowess as a highly prized attribute among engineering graduates [5], [6].

The first cohort of scholarship students (S-STEM Scholars) enrolled in Fall 2024. There are 10 scholars in this cohort and they are receiving an average of 8,000 USD/year in scholarship funds. These students represent five of the six engineering majors at Rowan University. The S-STEM Scholars and 108 other students engaged in the ELC in the academic year 2024-2025. The ELC students attended biweekly seminars during the fall semester, two of which were focused on DEI topics (called Upstander Training and Overcoming Imposter Syndrome).

We are interested in understanding the impact of these interventions on students' sense of belonging, as it significantly influences overall success and retention rates [8]. To assess this impact, we developed and deployed surveys measuring three constructs, with a particular focus on first-year students' sense of belonging. The pre-survey was primarily developed by the project's external evaluator, Quality Measures LLC, and was constructed using two previously validated instruments. These instruments were detailed in papers by Ahn [8] and Hoffman [9]. Hoffman's work provided a robust foundation for measuring sense of belonging due to its well-established validity. In contrast, Ahn's instrument measures sense of belonging more directly, avoiding the need to use proxies derived from related concepts,

The pre-survey also allowed us to establish a baseline for understanding first-year engineering students' persistence, retention, and self-efficacy. Using these data, we can assess the impact of the ELC and S-STEM scholarship on these factors. The survey began by identifying the group to which each participant belonged (S-STEM Scholarship Recipient, ELC Member, or neither). The next section, consisting of 12 questions, asked students to evaluate how specific aspects of their program contribute to their academic and professional careers. These aspects included the First-Year Engineering Clinic, learning scientific communication and writing, ELC seminars, mentorship with faculty, mentorship with fellow scholars, and mentorship with academic advisors. Responses were measured on a Likert scale from 1 to 5, where 1 indicated 'Not Well at All,' 4 indicated 'Very Well,' and 5 indicated 'Unsure.' Although these questions were primarily intended for scholarship students, they were posed to all survey participants.

The next section of 13 questions (Appendix 1-13), relates to student perceived self-efficacy. These questions are posed on a Likert scale of 0 to 4, with 0 being "Unsure", 1 being "Never", and 4 being "Often." The next section of 12 questions (Appendix 14-25) relates to student's perceived sense of belonging. These questions are nearly all posed on a Likert scale of 1 to 4, with 1 being "Strongly Disagree" and 4 being "Strongly Agree." We also ask if a student feels overall that they belong to Rowan University. We added an open-ended question to prompt students to expand further on their sense of belonging. The next section of 7 questions (Appendix 26-32) relates to student persistence and retention. These questions are all posed on a Likert scale of 1 to 4, with 1 being "Not at All Likely", and 4 being "Very Likely." There are 8 additional questions (Appendix 33-39), related to DEI components. These questions are almost all posed on a Likert scale of 0 to 4, with 0 being "Unsure", 1 being "Strongly Disagree", and 4 being "Strongly Agree."

After these questions, the survey asks for demographic information: academic classification, major, gender, and race. There is the opportunity for students to submit their general comments in an open ended question at the end of the survey.

III. Methods

To establish a baseline from which to assess the ELC and S-STEM scholarship, we surveyed all first-year students in the college of engineering during their First-Year Engineering Clinic I (FEC I) course. These students were divided into three subgroups: Scholarship Students (SSTEM, n = 10 out of 10 SSTEM population), Non Scholarship Students in the ELC (ELC, n = 91, out of 102 ELC students), and students who were part of neither group (None, n = 132, out of 144 students). As described above, the survey was designed to assess student motivation (including self-efficacy, sense of belonging, and perceptions of the curriculum) as well as their perceptions of Diversity, Equity, and Inclusion (DEI).

Since this pre-survey is not an entirely validated instrument on its own, establishing validity was imperative. For this project, this validation process was completed through Exploratory Factor Analysis (EFA). EFA is used to reduce the data down to a more manageable set and identify underlying themes that may not have been obvious on first inspection [7].

TABLE I
ITEMS DELETED IN THE EFA MODEL

Item Number	Identificator
37	CurrDEI
39	SocietalImpact
27	DiffEngDegree
28	DiffNonEngDegree
30	PursueJob
32	PursueNonEngGrad
33	GPA
5	FutureCareer
11	DoWellFutureCourses
25	RowanBelong

It is also used to validate and test the reliability of a survey, by making sure it actually measures what it is intending to.

EFA was conducted on the pre-survey data to determine the validity of the instrument and to group and reduce these survey questions. Our initial assumption was that the EFA would result in four factors: Sense of Belonging, Self Efficacy, DEI, and Persistence & Retention. These assumptions were derived from the construction of the survey, as questions with similar themes were grouped together.

The EFA process was conducted simultaneously by two researchers using a pre-created template in R. First, the correlations between items were checked, and any item with a correlation above 0.9 was removed from the set. Next, a KMO test was conducted to determine if the data were suitable for factor analysis. The KMO value was above the desired threshold of 0.5. Parallel analysis was then performed to estimate the number of factors to retain for the EFA. Based on the Scree Plot output, it was determined that starting with 6 factors would be optimal, with adjustments made as necessary.

Finally, the EFA was run in a ProMax rotation to produce an output similar to Table 1. Items that were loading in multiple factors or not loading at all were deleted first. Then, items loading at a communality score (h2) of less than 0.3 were deleted one by one. Typically the suggested cutoff is a communality score below 0.4 [7], but an adjustment was made because too many items would have been deleted with a 0.4 cutoff in this dataset. As the loadings would change slightly after every deletion, the EFA was re-run every time to determine which item should be deleted next. Items with the lowest h2 score were deleted first, until all items had an h2 score of or greater than 0.3, and were loaded in only one factor each. 10 items were deleted from the initial 39. They were as follows:

The actual items in the survey are presented in the Appendix. To create a better model, we will collect more data run an EFA and CFA in further analysis.

RESULTS

In total, 233 responses to the survey were kept after data cleaning. As shown in Table 2, the EFA resulted in the pre-survey questions being integrated into 6 factors:

1. Confidence with Professor: it contained 2 items, which appeared to measure a students perceived level of comfort and confidence with their professors (e.g. “I feel comfortable engaging with a faculty member outside of class.”)

2. Sense of Belonging: it contained 10 items which appeared to measure a students perceived sense of belonging at X University (e.g. “I believe the people at X understand me as a person.”)

3. Engineering Identity: it contained 3 items and appeared to measure a students feeling that they were capable of being an engineer (e.g. “I believe I am the type of person who can do engineering.”)

4. Goals and Intent to Pursue. It contained 3 items which appeared to measure a students feeling about the likelihood of continuing their studies and engaging outside of class (e.g. how likely do you believe you are to “Pursue graduate studies in engineering fields.”)

5. Test Assignment Confidence. It contained 8 items which appeared to measure a students perceived confidence with test taking and completing coursework in their engineering classes (e.g. “I believe I can do well on a test in my engineering program.”)

6. DEI Components contained. It contained 3 items which appeared to measure students frequency of engaging with diversity, equity, and inclusion issues at X University. (e.g. “I engage with conversations about equity, diversity, and inclusion with peers at X.”)

Descriptive statistics were run on the newly constructed variables, and displayed high kurtosis values, which could point to outliers in the data. Despite the lack of normality in the data, an ANOVA was run once between the new factors and the groups of ELC, SSTEM, and non ELC/SSTEM. Nothing was found to be statistically significant between the three groups, except in the Goals and Intent to Pursue factor, which showed that Scholarship students are statistically lower in this category than ELC students or students in neither group (Fig. 1). This means that at the beginning of their career, SSTEM students felt less likely to complete their undergraduate degree, pursue undergraduate research opportunities, and pursue graduate studies in the engineering field [11].

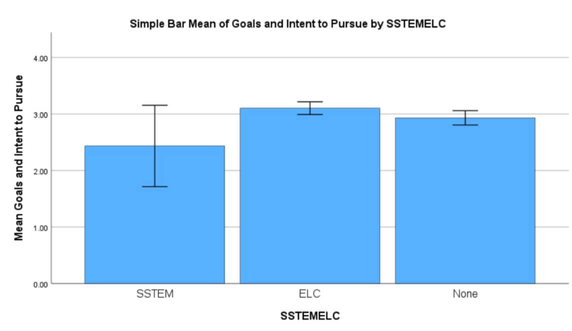

Fig. 1. Goals and Intent to Pursue between SSTEM, ELC, and None.

DISCUSSIONS & CONCLUSIONS

During the EFA process, the survey questions were grouped by the underlying variables. The variables were eventually la-

TABLE II
FINAL EFA TABLE

	item	MR1	MR2	MR5	MR3	MR4	MR6	h2
InstructorRespect	14	0.836						0.616
StaffRespect	15	0.812						0.631
StudentRespect	16	0.762						0.585
RowanWelcoming	18	0.732						0.499
TalkToInstructor	17	0.694						0.524
TalkToPeer	22	0.633						0.429
RowanMatter	21	0.606						0.521
HappyAtRowan	13	0.598						0.358
TalkToAdvisor	19	0.596						0.424
RowanUnderstand	20	0.564						0.446
TestDoWell	2		0.813					0.570
CompleteAssignments	3		0.698					0.410
LearnWell	7		0.601					0.465
AInEngCourse	6		0.561					0.444
TestConfidence	8		0.550					0.480
UnderstandContent	5		0.527					0.436
CanDoAssignments	10		0.510					0.437
CurrFamiliar	27		0.369					0.375
CanDoEng	9			0.801				0.684
GoodAtEng	4			0.629				0.494
ThinkLikeEngineer	11			0.521				0.335
DEIInstructor	28				0.811			0.668
DEIPeers	26				0.796			0.645
InequityBias	29				0.480			0.315
Questions	1					0.615		0.416
FacultyEngageComfort	12					0.612		0.395
UndergradResearch	24						0.587	0.328
PursueEngGrad	25						0.495	0.335
CompleteDegreeEng	23						0.362	0.374

beled as the 6 factors used for the analysis process: Confidence with Professor, Sense of Belonging, Engineering Identity, Goals and Intent to Pursue, Test & Assignment Confidence, and DEI Components.

The questions that comprise the Confidence with the professor, Engineering Identity, and Test & Assignment Confidence factors were originally identified as belonging to the Self-Efficacy category. Whereas most other items remained in the same categories they were originally conceived before the EFA process, except by the item 27 "CurrFamiliar", which asked students to rate their agreement with the statement: "I am familiar with the curriculum I have chosen within the engineering program at Rowan." was initially under the DEI category, but was re-categorized under the Test & Assignment Confidence factor after EFA.

Many factors could be contributing to the Scholarship students' responses with less intent to pursue than the ELC and Non-Scholarship students. It could be simply due to the high kurtosis issue discussed earlier, or the fact that the Scholarship student group is so small (n = 10). As the students were selected due to their economic status, they could be feeling like they may be financially unable to finish college. Many of the Scholarship students are first generation college students as well, and may feel a similar level of anxiety about expectations to finish [10]. More research and future data collection with new cohorts will help us answer these questions.

Additionally, since the Goals and Intent to Pursue construct includes statements about pursuing undergraduate research, scholarship students may be less likely to pursue such activities, due to time constraints. Although the S-STEM scholarship is intended to support outstanding financial needs, many SSTEM students reported having to work campus jobs to pay for other basic needs. Moreover, due to potential financial instability, the Scholarship students may feel that they would not be able to fund further studies past their bachelors degree. Though it could be a lack of interest, or wanting to jump-start a career right after graduation, many students of all financial backgrounds feel that graduate school is too expensive.

When the post-survey data has been collected and cleaned, Confirmatory Factor Analysis (CFA) will be run to confirm the findings from the EFA. Once the 6 factors are confirmed to be valid, the same statistical tests will be run on the post-survey data, as well as compared with the pre-survey data. It is expected that there will be a positive increase in all factors, particularly among the Scholarship and ELC students. As mentioned previously, assessing the impact of the interventions described in this paper is part of the future work of this project.

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Appendix

Survey items are in the order they appeared to students taking it. This includes all items discussed in the EFA process, both kept and deleted.

1. Questions - I am confident enough to ask questions in a class in my engineering program (Biomedical Engineering, Electrical Engineering, Mechanical Engineering, etc.).

2. TestDoWell - I believe I can do well on a test in my engineering program.

3. CompleteAssignments - I believe I can complete all of the assignments in a course in my engineering program.

4. GoodAtEng - I believe I am the kind of person who is good at engineering.

5. FutureCareer - I believe I will be able to use my engineering program in my future career when needed.

6. UnderstandContent - I believe I can understand the content in an engineering course.

7. AInEngCourse - I believe I can get an "A" when I am in an engineering course.

8. LearnWell - I believe I can learn well in an engineering course.

9. TestConfidence - I feel confident when taking a test in my engineering program.

10. CanDoEng - I believe I am the type of person who can do engineering.

11. DoWellFutureCourses - I feel that I will be able to do well in future engineering courses.

12 CanDoAssignments - I believe I can do the assignments in an engineering course.

13. ThinkLikeEngineer - I believe I can think like a engineer.

14. FacultyEngageComfort - I feel comfortable engaging with a faculty member outside of class.

15. HappyAtRowan - I am happy with my choice to be a student at Rowan.

16. InstructorRespect - I am respected by the university faculty (instructors) at Rowan.

17. StaffRespect - I am respected by the university staff (non-instructors) at Rowan.

18. StudentRespect - I am respected by other students at Rowan.

19. TalkToInstructor - I can talk to an instructor if I have a problem.

20. RowanWelcoming - I have found Rowan to be welcoming.

21. TalkToAdvisor - I can talk to my advisor if I have a problem.

22. RowanUnderstand - I believe the people at Rowan understand me as a person.

23. RowanMatter - I believe that I matter to others at Rowan.

24. TalkToPeer - I can talk a fellow student if I have a problem.

25. RowanBelong - Overall, I believe that I belong at Rowan.

26. CompleteDegreeEng - Complete my undergraduate degree in Engineering

27. DiffEngDegree - Choose a different engineering degree

28. DiffNonEngDegree - Choose a different degree that is not engineering

29. UndegradResearch - Seek research opportunities during my undergraduate experience

30. PursueJob - Seek employment immediately after completing my undergraduate degree

31. PursueEngGrad - Pursue graduate studies in engineering fields

32. PursueNonEngGrad - Pursue graduate studies not in engineering fields

33. GPA - What grade point average (GPA) do you believe you will have when you graduate with your undergraduate degree?

34. DEIPeers - I engage in conversations about equity, diversity, and inclusion with peers at Rowan.

35. CurrFamiliar - I am familiar with the curriculum I have chosen within the engineering program at Rowan.

36. DEIInstructor - I engage in conversations about equity, diversity and inclusion with instructors within my engineering program.

37. CurrDEI - I believe the current engineering curriculum incorporates diverse perspectives and promotes inclusion.

38. InequityBias - I am confident in my ability to recognize and address issues of inequity and bias within the field of engineering.

39. SocietalImpact - I believe engineering education should include discussions about societal impacts of engineering solutions.