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Board 353: Preparing Resilient Individuals to Succeed in Engineering Through NSF S-STEM Program

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Preparing Resilient Individuals to Succeed in Engineering

Introduction

The Louisiana State University College of Engineering has implemented an NSF S-STEM program f***ocusing on the retention and success of underprepared students in engineering and Computer science at LSU***. The project, Preparing Resilient Individuals to Succeed in Engineering (PRISE), creates a scholarship to meet the financial needs of underprepared, low SES students for success in an engineering program (e.g., not calculus ready and low Advanced Placement coursework). This project works to fill the gap between a student's high school academic preparation and those skills needed to be a successful engineering student. Currently, many XX state high school students are not receiving sufficient academic preparation in mathematics and study skills to be successful in engineering, particularly in "high need" / low SES regions of the state. This paper provides an overview of the program and results through the first two years.

Program goals include: (1) Use the scholarships and programs to improve scholars' academic performance in engineering foundational courses; (2) Develop a resiliency program to increase College of Engineering (CoE) student retention by building upon a sense of community created through existing peer-based programs (Geisinger & Raman, 2013; Ikuma et al., 2019); and (3) Increase employers' recognition of low SES students' strengths and valuations of their employable competencies through a paid internship program.

The general objectives were established including; (1) ***New pathway to success.*** Scholars are provided a pathway to complete an engineering degree including direct education and intervention approaches for their engineering academic career (Geisinger & Raman, 2013) Scholars will be retained in the program and graduate at a statistically significant higher rate; goal 65-75%; (2) ***Reduce time to graduation.*** Underprepared BS engineering students typically require 6 to 7 years to graduate, and this program seeks to reduce the time by one year while their GPAs will statistically, significantly increase; **(3)** ***Enhance professional development***. The program will improve PRISE Scholars' professional and leadership skills through workshops and an experiential learning series and subsidized internship / co-op. **(4)** ***Increase employer awareness.*** Employers who evaluate PRISE interns will receive targeted training on the National Association of Colleges and Employers (NACE) research-based competencies.

Program Design and Activities

The program has: (1) **Developed academic workshops** based on proactive study habits and utilizing resources; (2) **Developed professional workshops** based on. National Association of Colleges and Employers' (NACE) Career Readiness Competencies, e.g., professionalism/work ethics, intercultural fluency, and communication; (3) Supported engineering bridge camp attendance; (4) Offered alternate degree pathways; (5) Provided Academic faculty and peer mentors; (6) Provided engineering freshmen course tutoring.

Thorough assessments are creating a refined, evidence-based model that can be utilized by other institutions to increase the success of underprepared engineering students with financial need. PRISE is designed to address academic climate, grades, high school preparation, career goals, self-efficacy, and confidence (Geisinger & Raman, 2013). The proposed theoretical framework (Figure

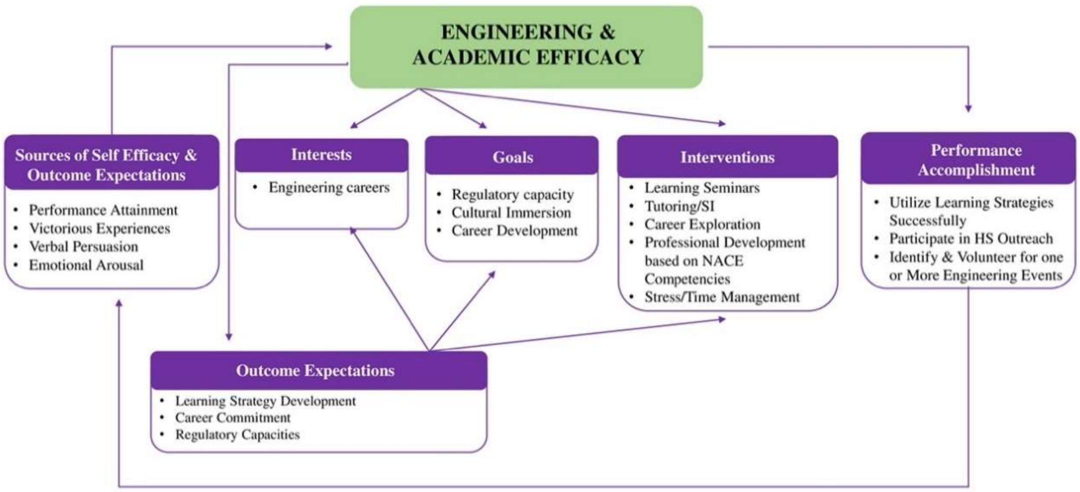

Figure 1: Project PRISE Theoretical Model

1) comes from several evidence-based perspectives: Social Learning Theory (Bandura, 1977) and Social Cognitive Career Theory (SCCT) (Lent et al.,1994).

Application and Selection Process

Applications were collected and reviewed for financial need/low-income criteria, and the resulting pool was evaluated for academic criteria (ACT and ALEKS scores. Due to LSU test optional policies some students did not have ACT or SAT scores or had older scores, and those applicants remained in the pool. All remaining applicants were fully reviewed by the selection committee. A rubric using 14 items totaling 100 points was used to evaluate, score, and rank each applicant. The ACT score was weighted to give more points to students in target range of 25-29. The scores/rankings for each student were averaged and ranked. The selection committee then discussed the applicants and final rankings.

Academic Readiness Activities/Foundational Academic Workshops

Bridge to Engineering Excellence: Incoming PRISE scholars were asked to participate in the Bridge to Engineering Excellence (BEE). This online six-week summer program for first-year engineering and computer science students provides review and preparation for differential and integral calculus, builds connections with current successful students, and introduces skills for becoming a successful student. Most PRISE scholars participated in this program. (Note: Identifying reference withheld will be added to final version).

EXCELD Tutoring: PRISE scholars were given priority consideration for the CoE EXCELD tutoring program for first-year students. EXCELD (EXcellence in Calculus/STEM for Engineering Leadership and Diversity) program is a tutoring initiative aimed at helping first-year engineering students excel in math, chemistry, physics, and biology. First-year engineering students are paired with engineering upperclassmen and required to meet with their assigned tutors twice a week per subject. During their freshman year, six cohort 1 Scholars participated in the fall and eight scholars attended tutoring in the spring. Analysis of the program impact is provided in the Results and Discussion: Assessments and Surveys section. Only 4 cohort 2

PRISE Scholars are currently actively participating in the program. (Note: Identifying reference withheld will be added to final version).

Academic Workshops: The PRISE scholars participated in three academic workshops during their first semester. The workshops were focused, one and half hour sessions. Each workshop was assessed for learning outcomes and perceived value. The content of each workshop is below.

> Time Management Workshop: The time management workshop seeks to improve students' time management skills by a) increasing knowledge of campus resources and b) increasing skill with using technology to prioritize and schedule. We also gathered information about students' experience of the workshop (the knowledge of the presenter, length of the session). Here we present the most salient results about student learning outcomes related to the workshop's objectives.

> Learning Styles and Study Groups Workshop**:** The learning styles and study groups workshop seeks to increase student's understanding of their results on the Felder/Solomon Engineering Learning Styles Index by learning about a) the different learning style indexes (e.g. active/reflective, visual/verbal, sensing/intuitive, and sequential/global), b) how these indexes manifest when learning new information, and c) what skills to use to adapt information from a professor to one's own unique learning style when studying. Prior to beginning the PRISE program, students were given a learning style inventory in July. In August, each met with a College of Engineering advisor and received their results and an explanation of the results. For this workshop, the objectives included: a) understanding learning styles in general and how they relate to learning; b) aligning study habits to learning styles. Pre/Post Results: 4 identified items were measured pre/post for the learning styles portion of this workshop. Likert scale for items = 1 (not knowledgeable at all) to 5 (very knowledgeable).

> Red Flags Workshop: Upon being oriented at LSU, students are made aware of the Student Code of Conduct and the expectations as to how they are to follow LSU policies. However, few students are aware of what their rights are in the classroom, nor do they fully understand how to professionally advocate for themselves. In this workshop, students are made aware of the policies at LSU that are in place to protect their academic pursuits and to keep course management fair and accessible to all students. Students learn how to professionally address difficult topics and how to approach their professors when the LSU policies are violated. They also learn the proper procedures to address issues that are not being addressed by their professors and the chain of command for complaints. Students also are informed about resources and agencies affiliated with LSU who are available to support them should they face an academic dilemma.

Career Development Workshops

The career development workshops were professional development oriented including four workshops based on the National Association of Colleges and Employers (NACE) competencies, and practical resume writing, and an ethics workshop. Each workshop was assessed for learning outcomes and perceived value.

Teamwork and Communications Workshop

The teamwork and communication workshop teaches basic skills of workplace teamwork and communication aligned to the NACE competencies. Information in the workshop included stages of team development, writing professional emails, and types of listening. Participants are given opportunities to practice skills through engaging activities such as identifying errors in professional emails and taking the MBTI assessment and participating in discussions about the results.

Career Development and Professionalism

The career development and professionalism workshop trains scholars on how to create a professional image and how to demonstrate to employers plans of self-improvement with a framework outlined by the NACE competencies. The workshop also stresses the importance of using assertive communication in a professional setting and how to create an elevator pitch. Participants are given the opportunity to apply skills through drafting and practicing their elevator pitches.

Resume Writing Workshop

The resume writing workshop educates students on how to create a resume that recruiters are excited to read. They go beyond the basic structure of a resume and dive into the psychology behind the words they choose and how they can get attention to their resume with proper wording and technique. The students learn about the process a recruiter uses to assess resumes to learn the importance of making critical information clear and easy to find. Students are introduced to a Mega Resume (curriculum vitae) to hold all their accomplishments and professional experience. This is then used to create their job-specific-tailored resume that they will use for applying for co-ops, internships and, eventually, full time engineering and computer science positions.

Diversity, Equity, Inclusion and Leadership

The diversity, equity, inclusion, and leadership workshop identifies the importance of DEI in the workplace as well as how to choose a suitable type of leadership for any situation, all in line with the NACE competencies. Participants engage in a strengths-based activity (called a Coat of Arms) in which they can identify and celebrate their own differences. Participants were encouraged to practice their knowledge of leadership in a group activity in which they role-play scenarios demonstrating each of the four leadership styles.

Ethics Workshop

The ethics workshop focused on making ethical decisions as a student and how that extends into professional ethics as they start their engineering and computer science careers. Students are lead through thought-provoking case studies where they find that making the “right choice” is not always as easy as it sounds. The facilitator and the students discuss how to weigh options and what points to consider with respect to ethical decision making.

Critical Thinking & Technology

The critical thinking and technology workshop facilitates discussion about technology and critical thinking in alignment with the NACE competencies. Participants are encouraged to engage in an open discussion about the evolving nature of technology in the workplace, in engineering, and in the general public. Moreover, to apply critical thinking skills, participants engage in a group activity called the Zin Obelisk in which they must navigate different communication and leadership styles to collectively solve a complex riddle.

Mentoring Element
The Mentoring Element has been implemented with PRISE scholars participating in the CoE Big Sibling program, a peer mentoring program, and matched with faculty who will guide them in their chosen major. Participation in Big Sibling was at 60 percent for cohort 1 with 46 percent frequently meeting with their mentor. When asked to provide feedback, reasons for not participating included "busy schedule" and "no need." Those who had multiple meetings with their mentor noted that it was "helpful," "informative," and guidance "to move through college."

Faculty mentors were asked to meet with their PRISE mentees at least twice per semester. However, the faculty and scholars were free to determine the frequency and types of meetings as best fit the individual mentor-mentee relationships. Initial reports indicate that this interaction was fruitful for scholars and faculty alike, and 73 percent of the scholars indicated that they met at least once with their mentor. The scholars reported that the faculty mentor meetings were helpful for finding research jobs, getting career outlook information, scheduling classes, and adjusting to college. This activity dovetails with our intention to increase PRISE scholars' exposure to the professors as partners in their success and to enhance the students' practice with engaging engineering professionals in general.

Assessments and Surveys
The PRISE assessments and surveys have been fully developed and administered via Qualtrics. The surveys on students' engineering self-efficacy (Mamaril et al., 2016, self-coping efficacy (Concannon and Barrow, 2009), engineering interest measure (Henderson et al., 2002), and career outcome expectations (Concannon and Barrow, 2009) have been administered as our main overall program learning outcome. Data collection was at pre-intervention (before students' first year), at mid-year (at the end of each fall semester), and post-intervention (end of each spring semester). Focus groups and/or individual interviews were used to evaluate scholars' attitudes regarding their collegiate experience, impact of the program on their success and experience, and overall engagement with the program. Student workshop pre- and post-survey data were collected to measure gain of knowledge and assess perceived value. Data was collected for each cohort with respect to their GPA performance, performance in STEM courses and their retention in the COE

Results and Discussion

Academics and retention.

The PRISE program selected two cohorts of 15 students each over the first two years. Overall, the scholars are doing well with a mean GPA of 3.504 for cohort 1 and 3.661 for cohort 2. All students have remained in the CoE and only one student has lost the scholarship when their GPA dropped below 2.7 two semesters in a row. (Table 1). It was observed that cohort 2 standardized test scores are lower than cohort 1 scores, but their first semester mean GPAs are the same.

Demographically, the group is diverse with underrepresented minorities at a level 10 percent higher than the CoE (Table 2). The number of female PRISE scholars is at 50 percent, and this is double the percent in the college (Table 3). The investigators are unsure at this point what contributed to the higher level of female representation.

Table 1. PRISE Academic performance and retention.

Academic Performance	Cohort 1 Mean	Cohort 2 Mean
High School GPA	4.198	4.095
ACT Composite	29.1	27.9
ACT Math	28.2	26.8
Semester 1 GPA overall	3.672	3.661
Semester 2 GPA overall	3.589	N/A
Semester 3 GPA overall	3.504	N/A
Retention CoE	100 %	100 %
Retention Scholarship	93.3 %	100%

Table 2. PRISE Scholar race and ethnicity.

Race/Ethnicity	Cohort 1	Cohort 2	Total #/%	CoE 2023
Asian	0	3	3/10%	8.1%
Black	3	4	7/23%	11.5%
Hispanic	1	0	1/3.3%	8.7%
White	10	6	16/53%	65.2%
2 or more	1	1	2/6.6%	2.6%
unknown	0	1	1/3.3%	0.8%
Total	15	15	30	3359
URM %	33.3%	33.3%	33.3%	23.1 %

Table 3. PRISE sex/gender.

Sex/Gender	Cohort 1	Cohort 2	Total
Male	10	5	15
Female	5	10	15

Workshops

For three of the academic workshops, cohort 1 students demonstrated significant improvement in knowledge in time management and learning styles.

a. Time Management Workshop Cohort 1: 12 participants attended and responded to the pre and post workshop surveys. Results revealed that an α= 0.05; t=11.3 at a critical value of 2.2, indicating a statistically significant change in participant knowledge gained regarding time management during the workshop. Cohort 2: 13 attended the workshop. Results did not demonstrate statistically significant growth based on pre and post workshop data analysis. α=0.05; t=11.3 at a critical value of 2.2
b. Learning Styles Workshop, 12 participants attended and responded to the pre and post workshop surveys. Results revealed that an α= 0.05; t=3.47; indicating a statistically significant change in participant knowledge gained regarding learning styles during the workshop.
c. Red Flags Workshop results were not statistically significant by a narrow margin. However, only 7 participants attended and responded to the pre and post workshop surveys (this workshop was held for students who did not attend the Geaux Engineering Red Flags workshop). Results revealed that at an α= 0.05; t=2.4 and a critical value of 2.47, the results reveal improvement in participant knowledge gained during the workshop, but it is not statistically significant.

Data was collected on the NACE professional workshops. Students demonstrated knowledge growth in all workshops. However, students attending the Teamwork and Communication and the Diversity, Equity, Inclusion and Leadership workshops had statistically significant growth in knowledge based on pre/post t-test results analysis. Data was not collected for the Resume writing and Ethics workshops but will be in future cohort years.

a. Teamwork and Communication
   df=10; $\bar{X}$ Pre=6; $\bar{X}$ Post=7; $p < .01$(sig.); $\bar{X}$ evaluation=4.52;
   Participant made gains in knowledge, and these gains were statistically significant.
b. Career Development and Professionalism *
   df=9; $\bar{X}$ Pre=3; $\bar{X}$ Post=3.1; $p < .01$(sig.); $\bar{X}$ evaluation=**4.79**
   Participant made gains in knowledge, but these gains were not statistically significant.
c. Resume Writing Workshop: No data collected
d. Diversity, Equity, Inclusion and Leadership *
   df=5; $\bar{X}$ Pre=2.167; $\bar{X}$ Post=4.167; $p < .01$(sig.); $\bar{X}$ evaluation=4.37
   Participant made gains in knowledge, and these gains were statistically significant.
e. Ethics Workshop: No data collected
f. Critical Thinking & Technology *

df=8; $\bar{X}$ Pre=1.167; $\bar{X}$ Post=2; $p < .01$(sig.); $\bar{X}$ evaluation=4.57
Participants made gains in knowledge, but these gains were not statistically significant.

Assessments and Surveys

Both cohorts 1 and 2 have completed the self-efficacy and engineering motivation surveys Table 4. Cohort 1 has completed the surveys four times, and cohort 2 has completed the surveys twice. Both cohorts showed an increase in self-efficacy for academic learning at the end of their respective first semester. It is notable that cohort 2 started college with a lower score of 7.48 versus cohort 2 at 8.15. However, both cohorts had the same self-efficacy level after the first semester. As more data points are gathered, a mixed ANOVA will be performed to test for differences between groups, changes over time, and whether the two groups changed at the same rate over time.

Table 4. PRISE scholars' efficacy and motivation results were repeatedly measured over time.

	Cohort 1				Cohort 2		
	Pre	Sem1	Sem2	Sem3	Pre	Sem1	Sem2
Self-Efficacy for Academic Learning (0–10-point scale)	8.15	9.25	9.05	8.87	7.48	9.25	
Engineering Motivation (7-point scale)							
Interest	6.44	6.67	6.55	6.44	6.30	6.67	
Attainment	6.07	6.51	6.34	6.26	6.29	6.51	
Utility	5.70	5.87	5.79	5.82	5.65	5.87	
Expectation	6.00	6.1	6.16	6.20	5.89	6.1	
Cost	4.19	4.4	4.65	5.22	4.62	4.4	
General Engineering Self-Efficacy (6-point scale)							
General	4.94	5.11	5.00	5.00	4.80	5.11	
Experimental Skills	4.82	4.99	5.08	5.20	4.45	4.99	
Tinkering	4.11	4.83	4.62	4.62	4.40	4.83	
Design	4.30	4.64	4.68	4.68	4.26	5.12	
Educational Outcome Expectancy (6-point scale)	5.49	5.73	5.6	5.55	5.31	5.38	
Career Outcome Expectancy (6-point scale)	4.81	4.84	4.72	4.90	4.80	4.67	

Self-Efficacy for Academic Learning Scale (Ernst et al., 2016) (Likert Scale 0-10).
Engineering Motivation Survey (Brown & Matusovich, 2013) (Likert Scale-7 point): This questionnaire contains 4 subscales.
General Engineering Self-Efficacy (Mamaril et al., 2016). This scale contains four subscales. Results by subscale indicated: General Engineering Self-Efficacy (GEN) Experimental SKILLS Self-efficacy; Tinkering Self-Efficacy; and Design Self-Efficacy

Educational Outcome Expectancy Scale (Springer et al., 2001) (Likert Scale 1-6). This scale contains 6 items.
Career Outcome Expectancy Scale (Springer et al., 2001) (Likert Scale 1-6). This scale contains 22 items, no subscales.

Conclusions

To date, the PRISE program at has selected two program cohorts with 15 scholars in each. Cohort 1 is in the second year, and 100 percent of the scholars were retained in engineering, and their mean first-year GPA was 3.59, which is well above the CoE mean of 2.75 (std. 0.80) and currently, 53 percent of the scholars are on track to graduate in four years based on flowchart reviews. Internal and external evaluations indicate that the program is overwhelmingly positive with the workshops cited as a top strength by the scholars. The workshop pre- and post-surveys indicated about half of the first-year workshops resulted in significant gains of knowledge. Adjustments to the surveys and content were made for cohort 2 and will be compared at the end of the 2023-24 academic year. The results of the self-efficacy and motivation survey indicate that the program and especially the workshop element, is having an impact, and future analysis with more data will be able to answer this research question. A third cohort will be selected and added for the 2024 academic year.

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