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WIP: Support to Success: How Institutional Resources Foster Increased Academic Outcomes for Marginalized Students in Electrical and Computer Engineering Departments

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Support to Success: How Institutional Resources Foster Increased Academic Outcomes for Underrepresented Students in Electrical and Computer Engineering Departments (WIP)

Existing literature well documents that women and students of color are underrepresented across STEM (science, technology, engineering, and mathematics) field majors and industry positions. Women comprise 47% of the workforce yet hold only 12% of engineering jobs [1]. Additionally, citizens who identify as Latino/a, Black, Native American, or Alaska Native together make up 27% of the U.S. population age 21 and older but hold only 11% of science and engineering positions [2].

Relative to other fields of engineering, electrical and computer engineering lag behind with women making up 19% and 18% of undergraduate degrees awarded, respectively. Underrepresentation of women in engineering majors and subsequent industry positions begins with an individual's *choice* to pursue this career field [3]. Difficulties in recruiting and retaining female-identified engineering students have been explained by availability, or absence, of environmental supports such as assistance in male-dominated teams [4] and positive relationships with advisors and mentors [5]. Conversely, negative gender stereotypes of women's engineering abilities deter women from entering or finishing an engineering major. For example, male-identified engineering students, when compared to their female-identified counterparts, endorsed more gender stereotypes about women, which may contribute to an unwelcoming environment [6]. Additionally, women in engineering have reported strained relationships with their male-identified classmates [7], which has been cited as a common barrier in pursuing engineering and STEM occupations post-graduation [8-9]. Students who do not feel welcomed nor identify as someone in that major may pursue an alternative career path.

Relatedly, there is underrepresentation of students of color in electrical and computer engineering (ECE), with Black men and Black women graduating at the lowest rates compared to other students of color, at 13.7% and 20.2%, respectively [10]. Furthermore, Black, Latino/a, and Native American students combined make up only 13% of engineering degrees awarded across all disciplines [11]. While the research on students of color is sparser than studies examining women, there is evidence to suggest that these students may internalize negative stereotypes, experience isolation and inadequate program support, and experience racism from students, staff, and faculty in engineering [12]. Four key areas of support have been identified for underrepresented students in engineering that positively influence community and sense of belonging, and therefore can contribute to persistence and retention. These supports include a) co-curricular/extracurricular involvement, b) peer support, c) faculty and departmental support, and d) residence programs [13].

National science training programs (STPs) have been implemented at universities to provide research experiences and student mentorship for these underrepresented groups with the aim to recruit, retain, and support these students. However, these programs vary in their design and targeted major within STEM fields. Certain majors have successfully diversified as a result of STPs while others remain homogenous. While there has been an improvement in representation of women and students who are minorities in the STEM field as a whole, this improvement is not uniform across majors and careers within STEM, with a pronounced gap in

engineering [14]. A proposed contributing factor is the male-dominated environment that lowers sense of belonging among women, thereby further perpetuating this gap [14]. Furthermore, there is an adjustment period within the first year of college that may bring additional challenges for students of color and set the stage for negative outcomes. For example, feelings of difference can negatively influence completing an engineering degree [15], whereas positive social integration has contributed to retention in engineering programs [16]. This adjustment period highlights two items of note: the need for continued support and/or the potential delayed benefits of interventions.

It is no surprise that a supportive learning environment would bring about student success and that historically underrepresented groups experience additional need for this support. Moreover, diversifying the gender and ethnic representation of ECpE graduates would yield a more diverse engineering work force more equipped to meet the challenges of tomorrow. Diverse teams are beneficial for an amalgam of moral, equitable, and innovative reasons including improved problem solving and improved work outcomes [17]. This representation and diversification is pertinent for professional and ethical advancement. Especially as the software and engineering (S&E) workforce continues to grow 3% faster than total employment growth [18], universities must rise to meet the demands of industry by fostering supportive learning environment for individuals of all backgrounds. Through postsecondary training, diverse workers would benefit industry through innovation, democratic decision making, and improved responsiveness to the public.

The current study builds on existing evidence-based practices shown to enhance student success, recruitment, and retention in a subfield of STEM that is predominantly White. Advancements in recruitment and retention for women and students of color have been made in prior years; however, fields such as electrical and computer engineering lag behind. To recruit, retain, and support underrepresented students better in electrical and computer engineering (ECpE), a large Midwestern university developed a multidisciplinary S-STEM: Scholarships for Science, Technology, Engineering, and Mathematics National Science Foundation (NSF) program. This program supports students financially, professionally, and interpersonally via scholarship funding, leadership development, and scholar seminars. Future research should explore the long-term academic outcomes compared to matched peers to better understand the lasting impact of program supports.

Method

Participants. Program scholars were matched to a control group of similar ECpE peers. Student data were obtained from the Office of the Registrar and matched by academic outcomes (high school GPA, standardized test scores) and demographic variables (sex, race).

The ESCEL Program. The Electrical, Computer, and Software Engineers as Leaders (ESCEL) program based on NSF funding (grant #1565130 S-STEM) was implemented and adapted to enhance student experience and scholarship programming. Students are enrolled annually within the program. This program utilizes evidence-based practices to enhance professional and leadership development through multifaceted interventions (e.g., weekly seminars, group activities, conference participations) and supports (e.g., faculty accessibility,

renewable scholarships). As part of the program, students participate in a weekly seminar aimed to advance personal and professional growth by creating a supportive space for students to share their experiences as an underrepresented electrical, computing, or software engineering major with peers and uplift engineering identity in participating students. Two goals of the ESCEL program were for these scholars to academically succeed as measured by their GPA and to persist in pursuing electrical, computer, and software engineering majors. Studies have shown that the extent to which female-identified students in engineering endorse their engineering identity is positively correlated with GPA and negatively correlated with likelihood of changing their major [5]. It was expected that after three semesters, program scholars would have significantly higher GPAs and would be retained at a higher rate, compared to the matched group. An independent samples *t*-test was used to compare the mean GPAs of the scholars' group and the matched group and a chi-square test was used to compare the proportion of students retained in the major of the scholars' group to the proportion of students retained in the matched group.

Data collection and analyses. Demographic data were collected via an annually distributed Qualtrics survey. Participants included 68 ESCEL scholars and 61 matched controls. Within the ECSEL scholar group, 23 identified as female students of color, 30 as White women, and 14 as male students of color. Program and control students were matched by GPA, gender, major, and a weighted formula including ACT composite score, high school cumulative GPA, and number of years of high school core courses. Data for the matched group were obtained from the Office of the Registrar at the university.

Results

A *t*-test analysis was used to determine if the mean GPAs of the scholar group and the control group were significantly different. Mean GPA did not differ after the first semester between program scholars ($M = 3.17$, $SD = .79$) and the control group ($M = 3.21$, $SD = .79$; $t = -.27$, $p = .78$) but did significantly differ after three semesters in the program. Program scholars' third semester GPA ($M = 3.32$, $SD = .57$) was significantly higher than their matched peers' GPA ($M = 2.96$, $SD = .81$; $t = 2.92$, $p = .004$). The magnitude of the effect was measured by a Cohen's *d* value of .51, or a difference of one-half of a standard deviation, which is considered a medium effect [21].

A chi-square analysis was used to compare the proportion of the scholars versus the proportion of the matched group who were retained. The proportion of program scholars who were retained (98.6%) compared to the matched control group (89.9%) was significantly higher ($\chi^2 = 5.45$, $p = .02$).

Discussion

Opportunities remain for the continued diversification of STEM fields. By investing in students at the individual and departmental level, a supportive environment can foster academic success for underrepresented students. Long-term support for these individuals may create spaces that are welcoming and supportive, therefore contributing to students' current and future academic success. These findings suggest that underrepresented students benefit from

department support, resulting in higher academic performance over time and enhanced retention. Additionally, the cumulation of support (i.e., financial, meetings with faculty, peer support groups, leadership opportunities) for underrepresented students in the program is beneficial and should be institutionalized where possible beyond the life of the grant. Due to the growth in industry positions and the success of future higher education institutions and organizations, it is timely to continue investing in women and in students of color in STEM fields, specifically in disciplines like electrical and computer engineering that lag behind.

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