



Building Community, Providing Scholarships, Developing Leaders: Recruiting and Retaining Underrepresented Students in Engineering and Computer Engineering Departments (WIP)

Mr. Kent A. Crick, Iowa State University

Kent Crick is currently in his third year as a graduate student at Iowa State University. He is currently a PhD candidate in Counseling Psychology and conducts research in self-determination as it relates to student and faculty motivation and well-being. Prior to attending Iowa State, he obtained a Master's Degree in Clinical Psychology from the University of Indianapolis. He then worked as a research coordinator for the Diabetes and Translational Research Center at the Indiana University School of Medicine in Indianapolis, IN for three years.

Mr. Matthew T. Seipel, Iowa State University

Dr. Lisa M. Larson Ph.D., Iowa State University

Prof. Mack Shelley, Iowa State University of Science and Technology

Mack Shelley holds the titled position of University Professor of Political Science, Statistics, and School of Education. He currently serves as Chair of the Department of Political Science. His research and teaching focuses on public policy. He has extensive experience with grants- and contracts-funded research and evaluation for federal and state agencies, and for nonprofit organizations.

Building Community, Providing Scholarships, Developing Leaders: Recruiting and Retaining Underrepresented Students in Engineering and Computer Engineering Departments (WIP)

The underrepresentation of women and people of color in engineering is well documented in the literature [1]. Women constitute 47% of the overall workforce but only 28% of jobs in science and engineering belong to women. This deficit is particularly noticeable in the fields of computer science and engineering as women comprise just 26% of the computer science workforce and hold only 15% of engineering positions. This gender divide begins to emerge at the undergraduate level, as women earn only 19% and 18% of bachelor's degrees awarded in engineering and computer science, respectively [2].

It has been hypothesized that these deficits of women in engineering fields have resulted from social marginalization. Specifically, Flam [3] argued that women experience a “chilly climate” when entering male-dominated fields. In such a climate, women receive direct and indirect messaging that their gender could be an obstacle to success in the work environment, which causes them to feel unwelcome. In such a climate, women often doubt whether they will be fully included, valued, and respected in the field despite their abilities [4], [5]. Further, women in science, technology, engineering, and mathematics (STEM) majors report notable levels of gender bias and sexual harassment within the context of their work [6]. Among women in STEM majors, experiences of STEM-related gender bias have been found to be related negatively to their career aspiration and motivation to pursue vocational opportunities in STEM [6]. In addition to messages of being unwelcome in the field, women in STEM fields have also been shown to encounter benevolent sexism (e.g., protective paternalism or gender differentiation) from their male peers [7]. This form of sexism has been linked with lower grade point averages (GPAs) in STEM courses [7]. These findings highlight the impact the academic climate can have on underrepresented students pursuing careers in STEM fields. Because GPA represents a primary achievement measure that carries important implications for one's academic trajectory, efforts to enhance representation of women and people of color in STEM fields can be evaluated using GPA.

Recent attempts to equalize gender representation in engineering fields provide evidence that rendering the academic climate more welcoming and supportive for women may narrow the gender gap. Specifically, Walton and colleagues [5] found that their social-belonging intervention and affirmation-training intervention aimed at enhancing a sense of connectedness among women in engineering majors resulted in significant increases in students' school-reported engineering GPAs. In addition to direct intervention, quality interactions with faculty [8] as well as courses utilizing active learning rather than a lecture-based approach have been shown to predict GPA among engineering students [9].

In a further effort to close this divide, a multidisciplinary Scholarships for Science, Technology, Engineering, and Mathematics (S-STEM) National Science Foundation (NSF) program was undertaken to recruit, retain, and develop leadership skills in underrepresented students majoring in electrical, computer, and software engineering (ECSE) at a large Midwestern university (computer science majors were not housed in this department). It was

hypothesized that the program would result in higher academic performance among program participants than in their non-participating peers, as indicated by their cumulative GPAs.

Method

Participants. Scholars included 63 students from two Midwestern junior colleges and one large Midwestern university with an average age of 20.94 years ($SD = 5.21$). Additional demographic information is presented in Table 1.

The ECSEL Program. The Electrical, Computer, and Software Engineers as Leaders (ECSEL) program was an effort to increase the retention of women and other underrepresented students in ECSE majors using grant funding received from the NSF (grant #1565130 S-STEM). Cohorts of students were enrolled in the program on an annual basis. Students enrolled in the ECSEL program received \$4,000 in scholarship funding for each semester they were enrolled in the program. In addition, students were required to participate in a leadership course with other ECSEL participants. This course was designed to promote professional development, community amongst the scholars, and connection to the campus community at large while enhancing their identity as ECSE majors. As a part of the course students were required to volunteer on campus, share current events with their fellow scholars, participate in in-class activities centered on leadership practices, participate in faculty mentor meetings and complete a reflection paper about that experience, and present to the class an artifact reflective of one's background. These activities were designed to cultivate an environment of support and connection among scholars while also engaging participants in an active learning experience. Such approaches have garnered support in the literature as being efficacious in improving the GPAs of underrepresented students in engineering majors [10], [11]. Specifically, the course was designed to provide a space for students to share their experience as an underrepresented ECSE major to create a sense of support amongst students that has been identified as necessary for improving student outcomes [10]. Further, the active learning component of the course was aimed at increasing the engineering identity of participating students, which has been positively associated with GPA in engineering students [11].

Data collection and analyses. Demographic data were collected annually from all scholars in the program using a Qualtrics survey distributed to students via email. Scholars' GPAs and the matched control students' GPAs were obtained from the Office of the Registrar at the university. The matching was based on gender, major, and a weighted formula that included ACT composite score, high school cumulative GPA, and number of years of high school core courses. Cumulative GPAs for the two groups were compared using an independent samples t -test [12]. This test statistic is associated with a probability value (p) ranging from 0 to 1 with a criterion value of $p < .05$ to establish a statistically significant difference. This value means that we can be at least 95% confident (100% - 5%) that the two groups' means are significantly different from each other in the population of all such students.

Results

Preliminary results indicated that after one semester in the program, the semester mean GPA of the ECSEL program scholars ($M = 3.24$, $SD = .79$) did not significantly differ from that of the

control group participants ($M = 3.00$, $SD = .87$; $t = -1.20$, $p = .24$). However, the semester mean GPA of the scholars after two semesters in the program ($M = 3.33$, $SD = .62$) was significantly higher than that of the matched control students ($M = 2.62$, $SD = .97$; $t = -3.46$, $p = .001$). This means that we can be 99.9% confident (100% - .1% from the p value) that the ESCEL scholars' mean semester GPA was significantly higher than that of the matched control students. Likewise, the cumulative mean GPA after three semesters in the program ($M = 3.32$, $SD = .42$) was significantly higher than that of the matched control students ($M = 2.76$, $SD = .40$; $t = -2.41$, $p = .03$). This means we can be 97% confident (100% - 3% from the p value) that the ESCEL scholars' cumulative mean GPA after three semesters was significantly higher than the matched control students' semester GPA. These two findings combined suggest that the ECSEL program's effect on scholars' GPA may be cumulative over time and beneficial compared to matched students who are not receiving the benefits of this program.

Discussion

The current literature indicates a lack of diversity in STEM fields. Findings from the current investigation indicate scholarship funding as well as departmental support designed to bolster the learning experience of underrepresented students (e.g., by providing a sense of community among peers, dedicated space, regular meetings with faculty, and leadership training) may result in prolonged enhancement of academic performance for these students. Further, such programming may render the learning space more welcoming and supportive of underrepresented students while also maximizing students' identity as an ECSE major. Improvements in these areas have the potential to enhance the academic performance and ECSE interest in a manner that facilitates retention of such students within these White male-dominated majors. Increasing the diversity of these fields will serve to advance national economic growth and advancement of these engineering fields as a whole. The limitations of this study include that no direct assessment was made of students' engagement with the various activities in the Leadership Studies course, although attendance was mandatory. Further, students were not separated into experimental conditions that allowed for the assessment of the efficacy of the scholarship money in isolation or the Leadership Studies course in isolation. Moreover, the sustainability of this support is in question due to resources being available because of grant funding. All participating students necessarily received both aspects of the program. Thus, it is unclear whether GPA improvement was due to the funding or the mentored faculty meetings. The strength of the study lies in the rigorous matched control group.

This material is based upon work supported by the National Science Foundation (NSF) under award EEC-1565130. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

Table 1. *Scholar Demographics*

	<i>N</i>	%
Gender		
Female	51	81
Male	10	16
Other	1	2
I choose not to respond	1	2
Race/Ethnicity		
Caucasian/White	34	54
Asian American/Pacific Islander	8	13
African American	7	11
Multiracial	6	9
Hispanic/Latino/a	5	8
I choose not to respond	2	3
Other	1	2
Major		
Computer Engineering	25	40
Software Engineering	20	32
Electrical Engineering	18	28

References

- [1] R. Lent, S. Brown, H. Sheu, and D. Treistman, "Social cognitive predictors of academic interests and goals in engineering: Utility for women and students at historically black universities," *Journal of Counseling Psychology*, vol. 52, (1), pp. 84-92, 2005.
- [2] National Science Board, "Chapter 3: Science and engineering labor force" in *Science & Engineering Indicators*, 2018. Available: <https://nsf.gov/statistics/2018/nsb20181/report/sections/science-and-engineering-labor-force>. [Accessed November 28, 2018].
- [3] F. Flam, "Still a 'chilly climate' for women?" *Science*, vol. 252, (5013), pp. 1604-1606, 1991.
- [4] C. Good, A. Rattan, and C. S. Dweck, "Why do women opt out? Sense of belonging and women's representation in mathematics," *Journal of Personality and Social Psychology*, vol. 102, (4), pp. 700-717, 2012.
- [5] G. M. Walton, C. Logel, J. M. Peach, S. J. Spencer, and M. P. Zanna, "Two brief interventions to mitigate a "chilly climate" transform women's experience, relationships, and achievement in engineering," *Journal of Educational Psychology*, vol. 107, (2), pp. 468-485, 2015.
- [6] C. Leaper and C. R. Starr, "Helping and hindering undergraduate women's STEM motivation: Experiences with STEM encouragement, STEM-related gender bias, and sexual harassment," *Psychology of Women Quarterly*, vol. 43, (2), pp. 165-183, 2019.
- [7] S. L. Kuchynka et al, "Hostile and benevolent sexism and college women's STEM outcomes," *Psychology of Women Quarterly*, vol. 42, (1), pp. 72-87, 2018.
- [8] S. L. Dika. "Relations with faculty as social capital for college students: Evidence from Puerto Rico." *Journal of College Student Development*, vol. 53, (4), p. 596-610, 2012.
- [9] S. Freeman et al, "Active learning increases student performance in science, engineering, and mathematics," *PNAS Proceedings of the National Academy of Sciences of the United States of America*, vol. 111 (23), pp. 8410-8414, 2014.
- [10] E. M. Dell, Y. Veerhoeven, J. W. Christman, and R. D. Garrick, "Using Self-Determination Theory to build communities of support to aid in the retention of women in engineering", *European Journal of Engineering Education*, vol. 43, (3), 2018, pp. 344-359.
- [11] B. Jones, C. Ruff, and M. Paretto, "The impact of engineering identification and stereotypes on undergraduate women's achievement and persistence in engineering," *Social Psychology of Education*, vol. 16, (3), 2013, pp. 471- 493.
- [12] B. G. Tabachnick and L. S. Fidell. "A guide to statistical techniques: Using the book." In *Using Multivariate Statistics*, 7th edition. New York, NY: Pearson, pp. 15-28, 2019.