

# Belonging in Engineering for Black, Latinx, and Indigenous Students: Promising Results from an Educational Intervention in an Introductory Programming Course

Allison Godwin, Heather Perkins, Linda DeAngelo, Eric McChesney, Kevin Kaufman-Ortiz, Gerard Dorvé-Lewis, Beverly Conrique

**Abstract—Contribution:** This study demonstrates the efficacy of an ecological belonging intervention in a first-year engineering programming course to increase belonging for Black, Latinx, and Indigenous (BLI) students and close academic equity gaps.

**Background:** Introductory programming courses are often challenging for students and can shape belonging in engineering. BLI students may be particularly susceptible to interpreting struggle as confirmation that they do not belong in predominantly white spaces, which can negatively influence academic outcomes.

**Research Questions:** “What are the effects of an ecological belonging intervention on BLI students’ feelings of belonging within their first-year engineering course?” and “What are the effects of an ecological belonging intervention on BLI students’ performance on a weekly computer programming assignment?”

**Methodology:** The intervention was implemented with 691 students in Spring 2022 and was designed to normalize struggle to address threats to belonging and close equity gaps in BLI students’ academic performance. A pre/post semester survey measuring belonging was analyzed using repeated measures ANOVA, and pass/fail academic records were analyzed using logistic regression.

**Findings:** The targeted belonging intervention for BLI engineering students can help to address issues of isolation and academic confidence that negatively impact individuals’ sense of belonging and academic performance.

**Index Terms—**Ecological belonging intervention; First year engineering; Social belonging; Stereotype threat

## I. INTRODUCTION

COMPUTER programming concepts have become essential to the engineering profession and part of requisite courses for most degree fields [1], [2]. However, the process of learning programming concepts is often challenging for students as it requires identifying the

problem and key features, formulating a solution strategy, translating the plan into the appropriate syntax, applying logic correctly, and debugging errors within the code in order for a script to run successfully [3]. Additionally, these skills are unique to programming [4], and students are often expected to learn these metacognitive skills alongside syntax and content [5]. Because of these challenges, the first programming course engineering students take can be a key signal about their abilities to succeed in engineering and their feelings of belonging within their degree program [6], which in turn have been shown to predict motivation, engagement, and academic performance in STEM majors [7]–[9].

Alongside these general challenges students face in learning computer programming, students who are systematically excluded and marginalized face additional threats to their belonging above and beyond their peers [10]–[12]. The exclusion and marginalization that Black, Latinx, and Indigenous (BLI) students experience is well documented in engineering [13], [14]. The barriers BLI students experience include feelings of isolation, invisibility, lack of belonging, and imposter syndrome which can adversely affect BLI students’ academic performance [15]–[19]. BLI students are also uniquely affected by pervasive whiteness in engineering culture, particularly at Predominately White Institutions (PWIs), which account for the most common and largest engineering programs in the United States [20]. BLI students report a variety of unique challenges, including unwelcoming classroom environments, imposter syndrome, macro- and microaggressions, systemic racism, and stereotype threat in their engineering experiences [21], [22].

Two factors, in particular, appear to motivate attrition from the engineering and programming fields: stereotype threat and

This work was supported by the National Science Foundation, under grant agreements 2111114 and 2111513. 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 National Science Foundation.

Allison Godwin is with the Robert Frederick Smith School of Chemical and Biomolecular Engineering, Cornell University, Ithaca, NY 14853 USA (email: afg64@cornell.edu).

Heather Perkins is with the Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN 47405 USA (e-mail: hlperkin@iu.edu).

Linda DeAngelo is with the Department of Educational Foundations, Organizations, and Policy, University of Pittsburgh, Pittsburgh, PA 15260 USA (e-mail: deangelo@pitt.edu)

Eric McChesney is with the Learning Research and Development Center, University of Pittsburgh, Pittsburgh, PA 15260 USA (e-mail: erm216@pitt.edu).

Kevin Kaufman-Ortiz is with the School of Engineering Education, Purdue University, West Lafayette, IN 47907 USA (e-mail: kaufmano@purdue.edu).

Gerard Dorvé-Lewis is with the Department of Educational Foundations, Organizations, and Policy, University of Pittsburgh, Pittsburgh, PA 15260 USA (e-mail: gdorvelewis@pitt.edu).

Beverly Conrique is with the Department of Psychology University of Pittsburgh, Pittsburgh, PA 15260 USA (e-mail: bconrique@pitt.edu).

The human subjects research was approved by Purdue University under IRB-2021-1739 and IRB-2021-1740.

lack of social belonging. As described by Steele and Aronson [23] and Spencer et al. [24] stereotype threat occurs when a member of a stereotyped group unconsciously devotes part of their working memory to behaving in ways that do not confirm negative stereotypes, imposing a significant cognitive burden on the student. In engineering programming contexts, “geek culture” can create dissonance between BLI students’ salient identities and the stereotypical image of a programmer—a smart “techy” White or Asian man with poor social skills [25]–[28]. BLI students may face racial stereotypes implying that they are less competent in subjects and skills pertinent to engineering and programming, which can undermine their academic success and reduce their persistence in STEM fields [19], [29]–[31]. These stereotypes, which are inconsistent with the role of a “good” engineer, force them to grapple with the exclusionary effects of systemic racism and often require self-reauthoring to conform within engineering spaces [17], [32].

Social belonging, “a sense of having positive relations with others” refers to feelings of being accepted, supported, connected, and is often reduced by the experience of being minoritized [33, p. 1447]. Having a strong sense of belonging is associated with retention, persistence, academic adjustment, and academic achievement [11], [18], [34]–[36], whereas belonging uncertainty detracts from students’ ability to engage with and benefit from learning activities [37]. Belonging differences by race and gender exist across STEM broadly and engineering in particular [38]–[40]. These differences have been linked to lower self-efficacy [41], and greater barriers to success in engineering [19], [42]. As a result of these factors and others, BLI students comprise just 16.5% of all bachelor’s degree earners in engineering [43] and demonstrate higher rates of attrition from engineering and STEM overall [18], [44], [45].

Due to these layered threats to belonging, introductory engineering courses that include computer programming are a focal area for promoting equitable course outcomes. As BLI students continue to represent a larger share of the national populace [46], [47], higher education must address barriers that hinder opportunities by improving sense of belonging among these groups. Several studies have tested interventions to address stereotypes and support belonging for BLI students generally [12], [33], [48], for women in engineering [49], and for BLI students in biology and women in engineering-focused physics courses [37]. Many of these interventions describe general experiences for all students in college and are administered individually. This intervention is specifically contextualized to the struggles students experience in the target course, is delivered during class, and reshapes the social environment. This focus on the interaction between individuals within the classroom environment (i.e., students, teaching assistants, and instructors) makes the intervention ecological in nature. The present study extends and refines earlier work on an ecological belonging intervention in physics and biology [37] to the context of an introductory engineering programming course.

### A. Study Context, Purpose, and Research Questions

This study was conducted at a large, Midwest public R1 institution. Students interested in pursuing engineering degrees are admitted generally to the first-year engineering program and after a year of common science, mathematics, and engineering courses, they select and matriculate into one of 16 engineering degree programs. This study took place in Spring 2022 in a second semester, required first-year engineering course. This course focused on engineering decision making and data analysis using a common engineering tool, MATLAB. The institution is predominately White (54%), and BLI students make up 7% of the engineering undergraduate enrollment along with 16% Asian American, 4% multiracial, and 18% international students [20] (Note, the percentages reported have been rounded to the nearest whole percent to anonymize the institution).

Our analysis of institutional data revealed a consistent equity gap in BLI students’ performance in the course of 0.44 points on a 4.0 grade point average scale. This equity gap persisted across the previous four years and was the main reason for choosing this course for a belonging intervention. The same analysis did not reveal a gender equity gap. The purpose of this study was to test the efficacy of an ecological belonging intervention in this course context for BLI students. Six sections of the course participated in the study; three in a “business as usual” condition (i.e., control;  $n = 331$ ) and three who received the ecological belonging intervention ( $n = 360$ ). Changes in participants’ sense of belonging and grades in a MATLAB assignment were compared across experimental groups (students who received the intervention and those who did not) and across race/ethnicity (BLI and White/Asian students) in a 2x2x2 repeated-measures ANOVA (RM-ANOVA) for the first research question and with logistic regression for the second. The following research questions were addressed:

- RQ 1: What are the effects of an ecological belonging intervention on BLI student’s feelings of belonging within their first-year engineering course?
- RQ 2: What are the effects of an ecological belonging intervention on BLI student’s performance on a weekly computer programming assignment (using MATLAB software) in the course?

## II. INTERVENTION FRAMEWORK

The ecological belonging intervention employed extends the work started in Binning et al. [37] into an engineering context. This base-form intervention was adapted to the context of a required first-year engineering programming course (refer to [50] for details on the process of contextualizing the intervention for this course). Binning’s ecological approach was developed from prior social belonging interventions (refer to [51]), which taught students that adversity in college is both normal and surmountable. The ecological approach attempted to instill the same message, not just within individual students, but within the social system of the classroom. Namely, rather than being delivered in a lab setting as in prior work, the ecological approach targeted carefully selected populations—classrooms with specific, known academic equity gaps in performance by race/ethnicity, gender, or first-generation

college student status. The intervention was delivered in one class session and was designed to establish a classroom norm that adversity in the course is common and normal and these struggles tend to be temporary and surmountable with time and effort.

The ecological belonging intervention took approximately 40 minutes to administer and consisted of five activities. First, the instructor described common challenges that students have likely encountered and may be navigating (e.g., adjustment to college, time management, increased workload and challenge of course material, finding internships/co-ops). Then, students individually wrote about one of their current struggles and considered how it might be addressed and overcome in the future. Next, these challenges were normalized by presenting a collection of stories from students who previously completed the course. These stories were designed to convey an arc of a challenge, the realization that challenge is normal and surmountable with sustained effort, and the resolution of that challenge. After these stories were presented, students actively practiced and reinforced the message that struggle is normal and surmountable through discussion in groups of 3 to 5 students. They discuss two questions designed to give them exposure to diverse perspectives from their peers, allowing them to gain insight into their partners' knowledge and experiences [52].

The intervention was grounded in the theoretical considerations of Walton and Cohen's [12] concept of belonging uncertainty and Steele's [53] concept of stereotype threat. As defined by Walton and Cohen [12], belonging uncertainty occurs when members of stigmatized groups enter an environment in which they may not be able to develop firm social bonds due to stigma, resulting in hypervigilance, anxiety, and sensitivity to negative social dynamics. This psychological state manifests as an unconscious "broad-based hypothesis that 'people like me do not belong here'" [12, p. 83]. The unconscious hypothesis primes the student's attention, drawing it to potentially threatening cues that would otherwise pass without notice (i.e., hypervigilance).

Research demonstrates that BLI students disproportionately experience belonging uncertainty [54], which (re)produces disparities in college performance [55]. Specifically, belonging uncertainty modifies students' cognitive processing of academic adversity. Stigmatized students who experience academic challenge (like poor performance on an exam) are more likely to believe that their immutable characteristics are associated with their poor performance [56], [57] and consequently, they cannot become a member of a valued in-group in that academic context.

A second mechanism relating marginalized student identities to underperformance is stereotype threat. Stereotype threat is a risk of confirming negative stereotypes about one's racial, ethnic, gender, or cultural group, which can create high cognitive load and reduce academic focus and performance [58]. In order for stereotype threat to manifest, a student must believe (correctly or incorrectly) that others in their social environment hold a stereotype about their group (e.g., Black students are worse at engineering than White students; [58]).

When students are uncertain about their belonging in a context, like engineering, they are hypervigilant to cues from their environment that signal if they belong. This state requires a significant degree of attention and stress to regulate behavior in a manner that disconfirms the suspected stereotype [59], [60]. This self-monitoring depletes their available working memory for learning [61] and can artificially downregulate task performance by an average of .22-.64 standard deviations [62].

Both stereotype threat and belonging uncertainty may be addressed via social belonging interventions. Specifically, the knowledge that others who are "like me" have succeeded within a context that primes belonging uncertainty and stereotype threat has shown promise in countering these marginalizing experiences [63], [64]. Walton and Cohen [12] suggested that interventions that decouple cognitive attributions from race/ethnicity and emphasize that belonging uncertainty can come from feelings of challenge (a normal part of the learning process) and that these feelings can change over time are effective ways to address these unconscious states affecting student performance. This decoupling allows students to cognitively reframe their past and current experiences and indicates that feelings of lack of belonging are not diagnostic of their long-term belonging or success in the field. Resultantly, students are more psychosocially resistant to challenge as a signal that they do not belong, and are more likely to experience challenge as something they can change. In this way, social belonging interventions, such as the ecological belonging intervention employed in this study [37], are theorized to disrupt the negative feedback loops of belonging uncertainty, stereotype threat, and consequent underperformance.

### III. METHODS

#### A. Procedures

The intervention took place during the first week of classes in Spring 2022, during the second meeting of the class. Students in the control condition experienced business as usual and were not exposed to the intervention. The pre-survey was made available to students in all conditions during the first day of the class session and closed prior to the introduction of the intervention. The post-survey was opened during the last two weeks of class and closed prior to the beginning of finals week. All students were offered extra credit for completing the survey and were provided other extra credit opportunities if they did not wish to participate in this research study. As part of this survey, participants were asked about their sense of belonging, classroom norms, engagement, career aspirations, learning behaviors, and demographics including racial and ethnic identity, gender identity, sexual orientation, family background, and dis/ability. Data on course performance including the two major assignment types, individual MATLAB grades and a team-based project, were also collected to understand the impact of the intervention on closing the equity gap for BLI students in the course.

#### B. Participants

A total of 641 students completed the pre/post surveys (92.7% response rate across conditions), 307 in the control

sections and 334 in the experimental sections. Of these students, 1.7% identified as African American or Black, 5.5% as Latino/a/x, 0.8% as American Indian or Alaska Native, and 0.5% as Native Hawaiian or Pacific Islander. A total of 86.2% of students identified as White or Asian, and 29.1% preferred not to respond. The response options provided a multi-select option, so the percentages listed above may sum to more than one hundred percent (refer to Table I for more information about race/ethnicity and gender). Participants who identified as Black/African American, American Indian, Mexican, Central American, Puerto Rican, Other Latino/a/x, and Native Hawaiian/Pacific Islander were grouped into a larger category (BLI,  $n = 52$ ) for comparison against the non-BLI group ( $n = 589$ ). These figures include both students who are U.S citizens and international students. Although the research teams' preference would have been to model belonging separately for each BLI group, the study lacked the statistical power to do so and made the decision to group these students together within the analysis as, on the balance, assessing the potential efficacy of the intervention outweighed valid concerns [65].

TABLE I  
PARTICIPANT DEMOGRAPHICS

| Race/Ethnicity                                                         | Count | Percentage |
|------------------------------------------------------------------------|-------|------------|
| African American/Black*                                                | 11    | 1.7%       |
| American Indian/Alaska Native*                                         | 5     | 0.8%       |
| Arab, Middle Eastern or Persian                                        | 14    | 2.1%       |
| East Asian (e.g., Chinese, Japanese, Korean, Taiwanese)                | 41    | 6.3%       |
| Southeast Asian (e.g., Vietnamese, Thai, Laotian, Filipino, Malaysian) | 18    | 2.8%       |
| Indian/Pakistani                                                       | 54    | 8.3%       |
| Other Asian                                                            | 4     | 0.6%       |
| Mexican American/Chicano or Mexican*                                   | 11    | 1.7%       |
| Central American (e.g., Nicaraguan, Honduran)*                         | 8     | 1.2%       |
| Puerto Rican*                                                          | 1     | 0.2%       |
| Other Latinx*                                                          | 16    | 2.4%       |
| Native Hawaiian/Pacific Islander*                                      | 3     | 0.5%       |
| White/Caucasian                                                        | 433   | 66.2%      |
| Not listed above                                                       | 1     | 0.2%       |
| Prefer not to respond or no response                                   | 190   | 29.1%      |
| Gender Identity                                                        |       |            |
| Man                                                                    | 328   | 50.2%      |
| Woman                                                                  | 131   | 20.0%      |
| Non-binary or genderqueer                                              | 3     | 0.5%       |
| Not listed                                                             | 1     | 0.2%       |
| Prefer not to respond or no response                                   | 191   | 29.2%      |

\*coded as Black, Latino/a/x, or Indigenous (BLI) for analysis

Students were assigned to each section by the university registration process (i.e., not self-selected schedule). As such, this work represents a quasi-experimental research study design. Equivalency between demographic enrollment between control and experimental sections was verified with 5.2% of control sections BLI students, and 8.0% of experimental sections as BLI students. Instructors were recruited to participate in the study as either intervention sections or control sections. Three sections were recruited for treatment sections and three as intervention sections across 4 instructors. Each section had a maximum enrollment of 120 students and were similar in size.

### C. Measures

The first outcome variable, a measure of belonging in the classroom domain, was measured using three items ( $\alpha = .82$ ) that asked participants to agree or disagree with the statements on a 4-point Likert scale: “I feel comfortable in engineering”, “I feel I belong in engineering”, and “I enjoy being in engineering”. The second outcome variable, performance on a weekly MATLAB assignment, was measured using students' grades. The majority of students had high scores on this assignment, with the end-of-semester average above 96% for 70% of students. As a result, scores were dichotomized as pass ( $n = 561$ ) or fail ( $n = 43$ ; cutoff at .70, equivalent to the C-needed to pass the class). An analysis of overall grades and team-based project grades was also conducted and showed no statistically significant impact.

### D. Analysis

To test the hypothesis that the intervention would be significantly correlated with an increase in the sense of belonging among BLI students, but would have no significant effect upon White and Asian students, the research team performed a 2x2x2 repeated-measures ANOVA (RM-ANOVA) using the *afex* package in R [66]. Due to the longitudinal structure of the data, time was used as the within-groups variable, while identification as a BLI or non-BLI student and experimental condition (intervention or control) were the between-groups variables. Q-Q plots and skewness/kurtosis tests were used to verify the normality of the dependent variable. To account for unequal sample sizes among groups, Type III sums of squares was used. To examine the effects of the intervention and race/ethnicity on MATLAB grade, a logistic regression was run using the *glm()* function in R on students dichotomized MATLAB grade (passing grade of C- or higher versus non-passing grades). Students' grade on the class project was entered as a control, and multicollinearity was ruled out by examining VIF scores (all values below 4).

Both of these analyses were underpowered, owing to the low number of BLI engineering students. Previous work with highly underrepresented groups argues for the validity of such research and the need to consider how traditional statistical norms may hide or prevent study of “small  $n$ ” populations [67], [68]. To this end, this study uses a higher alpha value cutoff of 0.10 to interpret the findings. This approach attempts to balance statistical considerations with practical and equity concerns for students of marginalized populations.

### E. Team Positionality Statement

The research team of faculty, postdoctoral scholars, and graduate students included researchers from higher education, social psychology, and engineering education. One researcher has been engaged with the design and teaching of the course of study, which constitutes the research context. As Black, Latinx, and White scholars, these identities have influenced the teams' engagement with this research and decisions about measurement and the interpretation of results. The research team had regular discussions of our approach to research questions across our disciplinary domains including how the team frames marginalization in engineering and the potential positive and negative impacts of this work for BLI students. In

conducting this research and analysis, the research team has been cautious to interpret the results as promising while also acknowledging the limitation of a quantitative approach to understanding the individual experiences of students within the data and recognizing the need for qualitative and mixed methods research to support the findings described in this study.

#### IV. RESULTS

##### A. Belonging x Race/Ethnicity x Treatment

The effects of the intervention were tested, as moderated by race/ethnicity, on students' belonging using a three-factor split-plot (one within-subjects factor and two between-subjects factors) repeated-measures ANOVA. The within-subjects factor was time, which was measured at the start and finish of the semester. The between-subjects factors were racial self-identification as a BLI student or White and Asian student, and assignment to the treatment or control condition. Of the 641 students surveyed, 265 completed both phases of the survey and were used in the RM-ANOVA. There was not a significant amount of missing data (<5%), therefore data imputation was not used. No univariate outliers were detected. Because the within-subjects variable only had two levels, the assumption of sphericity was automatically met. A visual examination of the residual Q-Q plots demonstrated reasonable normality with moderate S-shaped lifting from the central line.

No statistically significant main effects were detected, but a statistically significant three-way interaction between BLI status, treatment condition, and time was detected ( $F(1,261) = 2.99, p = .085, \eta^2_p = .01$ ). This result indicates that BLI students in the treatment group had a statistically significant difference in pre/post belonging scores compared to the BLI students in the control group. Effect sizes for significant effects were small even with power well below that standard for the detection of effects in social scientific research. The full results of the repeated-measures ANOVA are presented in Table II and visualized in Fig. 1.

All student groups began the semester with average belonging scores above 3.0 on a 5.0 scale. White and Asian students in the control condition had consistent scores at pre ( $M = 3.11, SE = .05$ ) and post ( $M = 3.15, SE = .05$ ), while BLI students in the control condition reported a decrease in belonging from pre ( $M = 3.40, SD = .20$ ) to post ( $M = 3.20, SD = .19$ ). White and Asian students in the treatment condition reported slightly lower belonging from pre ( $M = 3.21, SE = .04$ ) to post ( $M = 3.16, SE = .04$ ), while BLI student's scores increased slightly from pre ( $M = 3.14, SE = .10$ ) to post ( $M = 3.17, SE = .09$ ).

TABLE II  
THREE-FACTOR SPLIT-PLOT ANOVA RESULTS

|                | F    | p     | $\eta^2_p$ |
|----------------|------|-------|------------|
| Main Effects   |      |       |            |
| Treatment      | 0.22 | 0.643 | <.001      |
| BLI x Majority | 0.45 | 0.504 | 0.002      |
| Treatment x    |      |       |            |
| Control        | 0.97 | 0.326 | 0.004      |
| Time           | 1.04 | 0.31  | 0.004      |
| Interactions   |      |       |            |
| Treatment x    |      |       |            |
| Time           | 0.54 | 0.465 | 0.002      |
| Race x Time    | 0.63 | 0.427 | 0.002      |
| Treatment x    |      |       |            |
| Race x Time    | 2.99 | 0.085 | 0.011      |

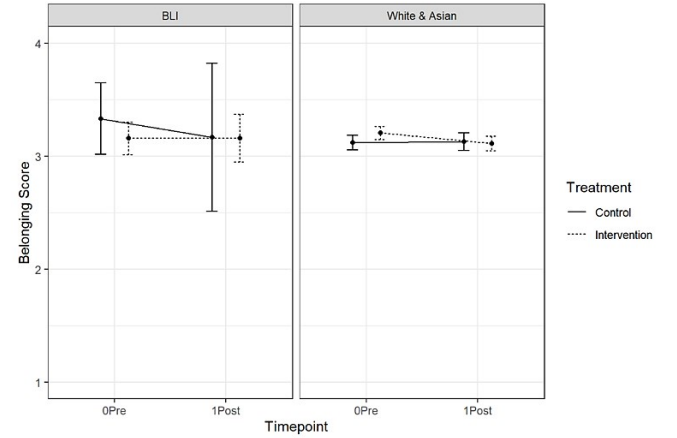


Fig. 1. Pre and Post Effects of Intervention on Majority and BLI Students.

##### B. MATLAB Grade x Race/Ethnicity x Treatment

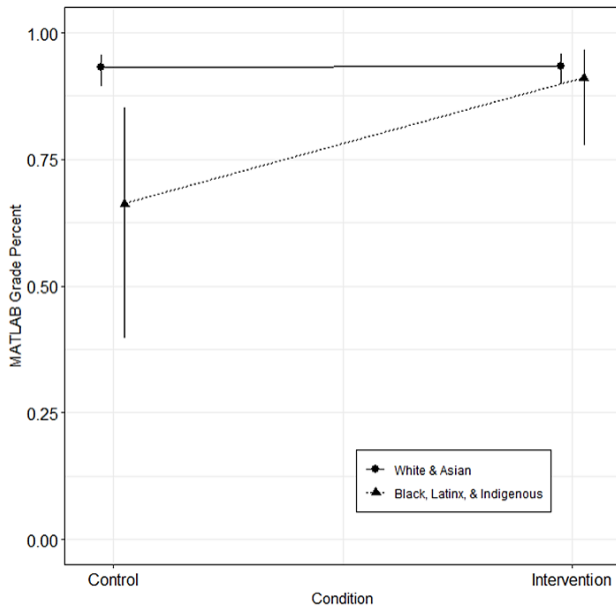
Of the 641 students surveyed, 38 did not have grades for the required assignments (MATLAB and class project) or the required demographic information ( $n = 603, 94\%$ ) and were excluded from this model. The effects of the intervention were tested, as moderated by race/ethnicity, on students' dichotomized MATLAB grades (pass vs. fail) using logistic regression and controlling for the class project grade (which was most of the remaining grade in the course, and was completed in teams of 3-4). The model was significant,  $\chi^2(4, N = 599) = 28.25, p < .001$ , explained 11% (Nagelkerke  $R^2$ ) of the variance in MATLAB grade, and correctly predicted 92.4% of cases. The odds of a passing grade increased by 80% ( $OR = 5.01, 95\% CI [0.25, 3.13]$ ) for BLI students in the intervention condition. BLI students in the intervention condition had an average MATLAB grade ( $M = .91, SE = .05$ ) .25 points higher than BLI students in the control condition ( $M = .66, SE = .04$ ),

TABLE III  
PARTICIPANT DEMOGRAPHICS

| Predictor              | B     | SE B | z-value | p     | OR     | Wald's $\chi^2$ | df | p     |
|------------------------|-------|------|---------|-------|--------|-----------------|----|-------|
| Constant               | -1.88 | 1.21 | -1.55   | 0.121 | -1.88  | 28.25           | 4  | <.001 |
| Project Grade          | 4.88  | 1.32 | 3.69    | <.001 | 132.48 |                 |    |       |
| Treatment              | 0.03  | 0.34 | 0.08    | 0.937 | 1.03   |                 |    |       |
| BLI Status             | -1.95 | 0.61 | -3.21   | 0.001 | 0.14   |                 |    |       |
| Treatment x BLI Status | 1.61  | 0.85 | 1.90    | 0.057 | 5.01   |                 |    |       |

Nagelkerke  $R^2 = .106$

while MATLAB grades held steady for White and Asian students across conditions (control:  $M = .93$ ,  $SE = .02$ ; intervention:  $M = .93$ ,  $SE = .02$  (refer to Table III for full results and a visualization of the interaction in Fig. 2).



**Fig. 2.** Effects of intervention on majority and BLI students' MATLAB grades.

## V. DISCUSSION AND IMPLICATIONS

The ecological belonging intervention had promising, but small effects, in addressing declines in BLI student belonging over the semester. White and Asian students entering the course had an average sense of belonging of 3.17 on a 5-point scale, which did not decline significantly over the semester, regardless of treatment or control assignment. In contrast, BLI students had an incoming sense of belonging scores similar to White and Asian students (3.17 on a 5-point scale) but experienced a statistically significant decline in belonging over the course of the semester in the control condition but not in the treatment condition (2.90 and 3.14, respectively). A general decline may not be unexpected as students normalize the role of being an engineer and the difficulty of learning new concepts. However, the decline in sense of belonging may have been higher for BLI in the control section than their White and Asian peers because of the additional stereotype and social belonging threats present [21], [22].

Based on these results, the ecological belonging intervention is hypothesized to work as a protective factor for this sense of belonging loss. Conveying the message that adversity is normal, surmountable, widely experienced, and manifests in different ways for *all* students can reshape the context of struggle for students in engineering courses that may threaten students' developing sense of self and their potential to succeed [37]. This message can support a reframing of students' interpretation of common struggle within this gateway programming course. Instead of struggle as a signal to BLI students that they may not belong in engineering, which erodes social belonging, struggle can be reframed as something that is not predicated upon students' minoritized status. This

reframing of struggle can also address stereotype threat that is primed in STEM contexts for BLI.

Significant research has supported the connection between stereotype threat and increased cognitive load reducing academic performance [61], [69]–[72]. This study also provided evidence that sense of belonging may be an important intermediary in addressing equity gaps in student performances where negative stereotypes exist about a group, an area that had not been directly tested previously. The intervention also appeared to close the academic equity gaps for BLI students on individual MATLAB programming assignments in the course. However, this intervention did not close the academic equity gap completely; the team-based course project still showed differences in academic performance, which indicates a need to further probe the team dynamics and equity of that project on students. Other research has shown the experience of students in diverse teams can have negative impacts on students through microaggressions, everyday experiences of racism, and teaming behaviors that emphasize engineering products over inclusive practices [73]–[75]. These marginalizing experiences may create additional barriers for addressing stereotype threat and belonging uncertainty within the team project.

These results have implications for both research and practice in engineering education. It is important to acknowledge that student outcomes in introductory engineering programs are not a direct result of student ability (a deficit-based approach to considering differences in academic performance). No data support the existence of differences in student abilities by control and treatment groups in this study, nor does admissions data indicate significant differences between groups. Instead, evidence suggests that the classroom environment is a key feature that interferes with students' abilities to achieve their full potential. Consequently, it is essential that engineering education research addresses students' sense of belonging as an intermediate factor in addressing equity gaps in student learning and academic performance.

## VI. LIMITATIONS AND FUTURE WORK

The above results should be interpreted with caution and interpreted as promising rather than conclusive because the data analyzed are based on a pilot study with small numbers of BLI students. The results indicate promising statistical significance in two of the three-way interactions: *Belonging x Race/Ethnicity x Treatment* and *MATLAB Grade x Race/Ethnicity x Treatment*. However, the impacts on closing the overall academic equity gap were not found. The intervention did not address academic equity gaps in the team project that was a large portion of the grade for the course in the latter half of the semester. Still, the results for the MATLAB programming assignments are promising in demonstrating that the ecological belonging intervention employed has efficacy in addressing at least some of the barriers to success in programming for BLI student engineers.

Additionally, due to the small sample sizes, student responses across Black, Latino/a/x, and Indigenous students had to be grouped together and contrasted with majority White and Asian students. These results may obscure the intervention's effectiveness for particular groups and only

provide a partial characterization of students' experiences [76]. This analytic approach could also reify a suboptimal normative comparison of marginalized groups to the "default" of White and Asian men in engineering [77]. Finally, small sample sizes prevented this research from examining the effects of the intervention at different intersections of gender and race/ethnicity.

Future work will employ larger samples to replicate this study within the same course. This additional data will provide more robust, sensitive results for intersectional investigation. This work will also investigate how the intervention implementation integrity (perceived authenticity of the faculty facilitator and ability to convey the core message that adversity is normal and surmountable) supports or undermines the effectiveness of the intervention in reshaping classroom norms to better support belonging and to address the effects of stereotype threat. This future work will also explore how faculty mindsets about diversity, equity, and inclusion; training; and integration of the intervention implementation affect the effectiveness of this intervention.

## VII. CONCLUSION

This study investigated the effectiveness of an ecological belonging intervention customized to a required first-year engineering programming course. To the research team's knowledge, this study was the first to focus specifically on first-year BLI engineering students' experiences following an ecological belonging intervention. The results indicated that the intervention acted as a protective psychosociological mechanism for BLI students' belonging during the semester and that the intervention closed academic equity gaps in individual course assignments. The results of this work emphasized that the theories of social belonging and stereotype threat are important aspects of student experiences to address in practice and that even small changes in the classroom norms, environment, and faculty approaches can support more equitable outcomes for students. The results of this study provide a low-effort, effective intervention to address longstanding equity gaps in engineering courses, which can have downstream effects on retention, engagement, and who ultimately becomes an engineer. As the U.S. becomes increasingly diverse, it is crucial to ensure that BLI students feel they belong in the engineering field and have a welcoming space in which to contribute to creative problem-solving.

## ACKNOWLEDGMENTS

The authors thank the editors and reviewers for their constructive comments, the participants (both students and instructors), and the UBelong Collaborative for their support in this research.

## REFERENCES

- [1] P. K. Chilana *et al.*, "Perceptions of non-CS majors in intro programming: The rise of the conversational programmer," in *2015 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*, Atlanta, GA: IEEE, Oct. 2015, pp. 251–259. doi: 10.1109/VLHCC.2015.7357224.
- [2] National Research Council, *Report of a Workshop on the Pedagogical Aspects of Computational Thinking*. Washington, D.C.: National Academies Press, 2011, p. 13170. doi: 10.17226/13170.
- [3] T. F. binti A. Rahman, N. Anuar, and R. F. M. Said, "How the nature of programming and learning materials affects novice learner's motivation and programming ability," in *Proceedings of the 6th International Conference on Information and Education Technology*, Osaka Japan: ACM, Jan. 2018, pp. 124–128. doi: 10.1145/3178158.3178184.
- [4] A. Baist and A. S. Pamungkas, "Analysis of student difficulties in computer programming," *VOLT J. Ilm. Pendidik. Tek. Elektro*, vol. 2, no. 2, p. 81, Oct. 2017, doi: 10.30870/volt.v2i2.2211.
- [5] A. J. Gomes, A. N. Santos, and A. J. Mendes, "A study on students' behaviours and attitudes towards learning to program," in *Proceedings of the 17th ACM annual conference on Innovation and technology in computer science education*, Haifa Israel: ACM, Jul. 2012, pp. 132–137. doi: 10.1145/2325296.2325331.
- [6] S. Secules, A. Gupta, A. Elby, and C. Turpen, "Zooming out from the struggling individual student: An account of the cultural construction of engineering ability in an undergraduate programming class: An account of the cultural construction of engineering ability," *J. Eng. Educ.*, vol. 107, no. 1, pp. 56–86, Jan. 2018, doi: 10.1002/jee.20191.
- [7] K. L. Lewis *et al.*, "Fitting in to move forward: Belonging, gender, and persistence in the physical sciences, technology, engineering, and mathematics (pSTEM)," *Psychol. Women Q.*, vol. 41, no. 4, pp. 420–436, Dec. 2017, doi: 10.1177/0361684317720186.
- [8] G. M. Walton, G. L. Cohen, D. Cwir, and S. J. Spencer, "Mere belonging: The power of social connections," *J. Pers. Soc. Psychol.*, vol. 102, no. 3, pp. 513–532, 2012, doi: 10.1037/a0025731.
- [9] S. Zumbunn, C. McKim, E. Buhs, and L. R. Hawley, "Support, belonging, motivation, and engagement in the college classroom: a mixed method study," *Instr. Sci.*, vol. 42, no. 5, pp. 661–684, Sep. 2014, doi: 10.1007/s11251-014-9310-0.
- [10] K.-A. Allen, M. L. Kern, C. S. Rozek, D. M. McInerney, and G. M. Slavich, "Belonging: a review of conceptual issues, an integrative framework, and directions for future research," *Aust. J. Psychol.*, vol. 73, no. 1, pp. 87–102, Jan. 2021, doi: 10.1080/00049530.2021.1883409.
- [11] T. L. Strayhorn, *College students' sense of belonging: a key to educational success for all students*, Second edition. New York: Routledge, 2018.
- [12] G. M. Walton and G. L. Cohen, "A question of belonging: Race, social fit, and achievement," *J. Pers. Soc. Psychol.*, vol. 92, no. 1, pp. 82–96, 2007, doi: 10.1037/0022-3514.92.1.82.
- [13] J. Holly, "Disentangling engineering education research's anti-Blackness," *J. Eng. Educ.*, vol. 109, no. 4, pp. 629–635, Oct. 2020, doi: 10.1002/jee.20364.
- [14] K. J. Jensen and K. J. Cross, "Engineering stress culture: Relationships among mental health, engineering identity, and sense of inclusion," *J. Eng. Educ.*, vol. 110, no. 2, pp. 371–392, Apr. 2021, doi: 10.1002/jee.20391.
- [15] R. Campbell-Montalvo *et al.*, "How stereotypes and relationships influence women and underrepresented minority students' fit in engineering," *J. Res. Sci. Teach.*, vol. 59, no. 4, pp. 656–692, Apr. 2022, doi: 10.1002/tea.21740.
- [16] D. Dortch and C. Patel, "Black undergraduate women and their sense of belonging in STEM at predominantly white institutions," *NASPA J. Women High. Educ.*, vol. 10, no. 2, pp. 202–215, May 2017, doi: 10.1080/19407882.2017.1331854.
- [17] E. Litzler and C. Samuelson, "How underrepresented minority engineering students derive a sense of belonging from engineering," in *2013 ASEE Annual Conference & Exposition Proceedings*, Atlanta, Georgia: ASEE Conferences, Jun. 2013, p. 23.674.1-23.674.20. doi: 10.18260/1-2--19688.
- [18] S. L. Rodriguez and J. M. Blaney, "'We're the unicorns in STEM': Understanding how academic and social experiences influence sense of belonging for Latina undergraduate students," *J. Divers. High. Educ.*, vol. 14, no. 3, pp. 441–455, Sep. 2021, doi: 10.1037/dhe0000176.
- [19] T. L. Strayhorn, L. Long, J. Kitchen, M. Williams, and M. Stentz, "Academic and Social Barriers to Black and Latino Male Collegians' Success in Engineering and Related STEM Fields," in *2013 ASEE Annual Conference & Exposition Proceedings*, Atlanta, Georgia: ASEE Conferences, Jun. 2013, p. 23.132.1-23.132.14. doi: 10.18260/1-2--19146.
- [20] American Society for Engineering Education, "Profiles of engineering and engineering technology," *Profiles of engineering and engineering*

- technology. <https://shinyapps.asee.org/apps/Profiles/> (accessed Mar. 13, 2023).
- [21] D. L. McCoy, C. L. Luedke, and R. Winkle-Wagner, "Encouraged or weeded out: Perspectives of students of color in the STEM disciplines on faculty interactions," *J. Coll. Stud. Dev.*, vol. 58, no. 5, pp. 657–673, 2017, doi: 10.1353/csd.2017.0052.
  - [22] E. O. McGee, *Black, brown, bruised: how racialized STEM education stifles innovation*. Cambridge, Massachusetts: Harvard Education Press, 2020.
  - [23] C. M. Steele and J. Aronson, "Stereotype threat and the intellectual test performance of African Americans," *J. Pers. Soc. Psychol.*, vol. 69, no. 5, pp. 797–811, 1995, doi: 10.1037/0022-3514.69.5.797.
  - [24] S. J. Spencer, C. M. Steele, and D. M. Quinn, "Stereotype Threat and Women's Math Performance," *J. Exp. Soc. Psychol.*, vol. 35, no. 1, pp. 4–28, Jan. 1999, doi: 10.1006/jesp.1998.1373.
  - [25] T. Camp, "'Computing, we have a problem ...,'" *ACM Inroads*, vol. 3, no. 4, pp. 34–40, Dec. 2012, doi: 10.1145/2381083.2381097.
  - [26] S. Cheryan, V. C. Plaut, C. Handron, and L. Hudson, "The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women," *Sex Roles*, vol. 69, no. 1–2, pp. 58–71, Jul. 2013, doi: 10.1007/s11199-013-0296-x.
  - [27] S. Lunn, M. Ross, Z. Hazari, M. A. Weiss, M. Georgiopoulos, and K. Christensen, "How do educational experiences predict computing identity?," *ACM Trans. Comput. Educ.*, vol. 22, no. 2, pp. 1–28, Jun. 2022, doi: 10.1145/3470653.
  - [28] A. Solomon, D. Moon, A. L. Roberts, and J. E. Gilbert, "Not Just Black and Not Just a Woman: Black Women Belonging in Computing," in *2018 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, Baltimore, MD: IEEE, Feb. 2018, pp. 1–5. doi: 10.1109/RESPECT.2018.8491700.
  - [29] M. A. Beasley and M. J. Fischer, "Why they leave: the impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors," *Soc. Psychol. Educ.*, vol. 15, no. 4, pp. 427–448, Dec. 2012, doi: 10.1007/s11218-012-9185-3.
  - [30] G. Lichtenstein, H. L. Chen, K. A. Smith, and T. A. Maldonado, "Retention and persistence of women and minorities along the engineering pathway in the United States," in *Cambridge Handbook of Engineering Education Research*, A. Johri and B. M. Olds, Eds., 1st ed. Cambridge University Press, 2014, pp. 311–334. doi: 10.1017/CBO9781139013451.021.
  - [31] E. Seymour and A. Hunter, Eds., *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Cham: Springer International Publishing, 2019. doi: 10.1007/978-3-030-25304-2.
  - [32] E. O. McGee, "Devalued black and latino racial identities: A by-product of STEM college culture?," *Am. Educ. Res. J.*, vol. 53, no. 6, pp. 1626–1662, Dec. 2016, doi: 10.3102/0002831216676572.
  - [33] G. M. Walton and G. L. Cohen, "A brief social-belonging intervention improves academic and health outcomes of minority students," *Science*, vol. 331, no. 6023, pp. 1447–1451, Mar. 2011, doi: 10.1126/science.1198364.
  - [34] L. J. Sax, J. M. Blaney, K. J. Lehman, S. L. Rodriguez, K. L. George, and C. Zavala, "Sense of belonging in computing: The Role of Introductory Courses for Women and Underrepresented Minority Students," *Soc. Sci.*, vol. 7, no. 8, p. 122, Jul. 2018, doi: 10.3390/socsci7080122.
  - [35] L. R. M. Hausmann, F. Ye, J. W. Schofield, and R. L. Woods, "Sense of belonging and persistence in white and African American first-year students," *Res. High. Educ.*, vol. 50, no. 7, pp. 649–669, Nov. 2009, doi: 10.1007/s11162-009-9137-8.
  - [36] S. Hurtado, J. C. Han, V. B. Sáenz, L. L. Espinosa, N. L. Cabrera, and O. S. Cerna, "Predicting transition and adjustment to college: biomedical and behavioral science aspirants' and minority students' first year of college," *Res. High. Educ.*, vol. 48, no. 7, pp. 841–887, Jul. 2007, doi: 10.1007/s11162-007-9051-x.
  - [37] K. R. Binning *et al.*, "Changing social contexts to foster equity in college science courses: An ecological-belonging intervention," *Psychol. Sci.*, vol. 31, no. 9, pp. 1059–1070, Sep. 2020, doi: 10.1177/0956797620929984.
  - [38] C. E. Foor, S. E. Walden, and D. A. Trytten, "'I wish that I belonged more in this whole engineering group:' Achieving individual diversity," *J. Eng. Educ.*, vol. 96, no. 2, pp. 103–115, Apr. 2007, doi: 10.1002/j.2168-9830.2007.tb00921.x.
  - [39] A. Kirm *et al.*, "Intersectionality of non-normative identities in the cultures of engineering," in *2016 ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 25448. doi: 10.18260/p.25448.
  - [40] K. Rainey, M. Dancy, R. Mickelson, E. Stearns, and S. Moller, "Race and gender differences in how sense of belonging influences decisions to major in STEM," *Int. J. STEM Educ.*, vol. 5, no. 1, p. 10, Dec. 2018, doi: 10.1186/s40594-018-0115-6.
  - [41] D. Verdin and A. Godwin, "First-generation college students identifying as future engineers," presented at the American Educational Research Association, New York, NY, 2018.
  - [42] A. True-Funk, C. Poleacovschi, G. Jones-Johnson, S. Feinstein, K. Smith, and S. Luster-Teasley, "Intersectional engineers: Diversity of gender and race microaggressions and their effects in engineering education," *J. Manag. Eng.*, vol. 37, no. 3, p. 04021002, May 2021, doi: 10.1061/(ASCE)ME.1943-5479.0000889.
  - [43] National Center for Science and Engineering Statistics, "Diversity and STEM: Women, minorities, and persons with disabilities," National Science Foundation, Alexandria, VA, Special Report NSF 23-315, 2023.
  - [44] K. Rainey, M. Dancy, R. Mickelson, E. Stearns, and S. Moller, "A descriptive study of race and gender differences in how instructional style and perceived professor care influence decisions to major in STEM," *Int. J. STEM Educ.*, vol. 6, no. 1, p. 6, Dec. 2019, doi: 10.1186/s40594-019-0159-2.
  - [45] J. O. Thomas, N. Joseph, A. Williams, C. Crum, and J. Burge, "Speaking Truth to Power: Exploring the Intersectional Experiences of Black Women in Computing," in *2018 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, Baltimore, MD, USA: IEEE, Feb. 2018, pp. 1–8. doi: 10.1109/RESPECT.2018.8491718.
  - [46] W. H. Frey, "The US will become 'minority white' in 2045, Census projects," *Brookings*, Mar. 14, 2018. <https://www.brookings.edu/blog/the-avenue/2018/03/14/the-us-will-become-minority-white-in-2045-census-projects/> (accessed Feb. 27, 2023).
  - [47] Pew Research Center, "Early benchmarks show 'Post-Millennials' on track to be most diverse, best-educated generation yet.," Nov. 2018.
  - [48] M. C. Murphy, M. Gopalan, E. R. Carter, K. T. U. Emerson, B. L. Bottoms, and G. M. Walton, "A customized belonging intervention improves retention of socially disadvantaged students at a broad-access university," *Sci. Adv.*, vol. 6, no. 29, p. eaba4677, Jul. 2020, doi: 10.1126/sciadv.aba4677.
  - [49] 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.," *J. Educ. Psychol.*, vol. 107, no. 2, pp. 468–485, May 2015, doi: 10.1037/a0037461.
  - [50] L. DeAngelo *et al.*, "Course-based adaptations of an ecological belonging intervention to transform engineering representation at scale," presented at the American Society for Engineering Education, Minneapolis, MN: American Society for Engineering Education, 2022. [Online]. Available: <https://peer.asee.org/41987>
  - [51] G. M. Walton and S. T. Brady, "The social-belonging intervention," in *Handbook of wise interventions: How social psychology can help people change*, A. J. Crum and G. M. Walton, Eds., New York, NY: Guilford Press, 2021, pp. 36–62.
  - [52] K. R. Binning and D. K. Sherman, "Categorization and communication in the face of prejudice: When describing perceptions changes what is perceived.," *J. Pers. Soc. Psychol.*, vol. 101, no. 2, pp. 321–336, 2011, doi: 10.1037/a0023153.
  - [53] C. Steele, *Whistling Vivaldi: how stereotypes affect us and what we can do*. New York, N.Y.: W.W. Norton & Co., 2011.
  - [54] D. S. Yeager *et al.*, "Teaching a lay theory before college narrows achievement gaps at scale," *Proc. Natl. Acad. Sci.*, vol. 113, no. 24, Jun. 2016, doi: 10.1073/pnas.1524360113.
  - [55] M. Gopalan and S. T. Brady, "College students' sense of belonging: A national perspective," *Educ. Res.*, vol. 49, no. 2, pp. 134–137, Mar. 2020, doi: 10.3102/0013189X19897622.
  - [56] C. S. Dweck, "Can personality be changed? The role of beliefs in personality and change," *Curr. Dir. Psychol. Sci.*, vol. 17, no. 6, pp. 391–394, Dec. 2008, doi: 10.1111/j.1467-8721.2008.00612.x.
  - [57] B. Weiner, "An attributional theory of achievement motivation and emotion.," *Psychol. Rev.*, vol. 92, no. 4, pp. 548–573, 1985, doi: 10.1037/0033-295X.92.4.548.

- [58] J. Aronson, M. J. Lustina, C. Good, K. Keough, C. M. Steele, and J. Brown, "When white men can't do math: Necessary and sufficient factors in stereotype threat," *J. Exp. Soc. Psychol.*, vol. 35, no. 1, pp. 29–46, Jan. 1999, doi: 10.1006/jesp.1998.1371.
- [59] T. Schmader, M. Johns, and C. Forbes, "An integrated process model of stereotype threat effects on performance.," *Psychol. Rev.*, vol. 115, no. 2, pp. 336–356, Apr. 2008, doi: 10.1037/0033-295X.115.2.336.
- [60] S. C. Wheeler and R. E. Petty, "The effects of stereotype activation on behavior: A review of possible mechanisms.," *Psychol. Bull.*, vol. 127, no. 6, pp. 797–826, 2001, doi: 10.1037/0033-2909.127.6.797.
- [61] T. Schmader and M. Johns, "Converging evidence that stereotype threat reduces working memory capacity.," *J. Pers. Soc. Psychol.*, vol. 85, no. 3, pp. 440–452, 2003, doi: 10.1037/0022-3514.85.3.440.
- [62] H.-H. D. Nguyen and A. M. Ryan, "Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence.," *J. Appl. Psychol.*, vol. 93, no. 6, pp. 1314–1334, 2008, doi: 10.1037/a0012702.
- [63] N. Dasgupta, "Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model," *Psychol. Inq.*, vol. 22, no. 4, pp. 231–246, Oct. 2011, doi: 10.1080/1047840X.2011.607313.
- [64] J. R. Shapiro, A. M. Williams, and M. Hambarchyan, "Are all interventions created equal? A multi-threat approach to tailoring stereotype threat interventions.," *J. Pers. Soc. Psychol.*, vol. 104, no. 2, pp. 277–288, 2013, doi: 10.1037/a0030461.
- [65] W. Castillo and D. Gilborn, "How to 'QuantCrit': Practices and questions for education data researchers and users," *EdWorkingPaper*, 2022, doi: 10.26300/V5KH-DD65.
- [66] H. Singmann, B. Bolker, J. Westfall, F. Aust, and M. S. Ben-Shachar, "afex: Analysis of Factorial Experiments." 2023. [R]. Available: <https://CRAN.R-project.org/package=afex>
- [67] C. D'Ignazio and L. F. Klein, *Data Feminism*. The MIT Press, 2020. doi: 10.7551/mitpress/11805.001.0001.
- [68] T. D. Mize, "Sexual orientation in the labor market," *Am. Sociol. Rev.*, vol. 81, no. 6, pp. 1132–1160, Dec. 2016, doi: 10.1177/0003122416674025.
- [69] A. E. Bell, S. J. Spencer, E. Iserman, and C. E. R. Logel, "Stereotype threat and women's performance in engineering," *J. Eng. Educ.*, vol. 92, no. 4, pp. 307–312, Oct. 2003, doi: 10.1002/j.2168-9830.2003.tb00774.x.
- [70] M. Inzlicht and T. Schmader, *Stereotype threat: Theory, process, and application*. Oxford University Press, 2011. doi: 10.1093/acprof:oso/9780199732449.001.0001.
- [71] D. L. Oswald and R. D. Harvey, "Hostile environments, stereotype threat, and math performance among undergraduate women," *Curr. Psychol.*, vol. 19, no. 4, pp. 338–356, Dec. 2000, doi: 10.1007/s12144-000-1025-5.
- [72] S. Spencer and A. Bell, "The Effect Of Stereotype Threat On Women's Performance On The Fundamentals Of Engineering Exam," in *2002 Annual Conference Proceedings*, Montreal, Canada: ASEE Conferences, Jun. 2002, p. 7.1144.1-7.1144.7. doi: 10.18260/1-2--11116.
- [73] J. Grant, S. Masta, A. Pawley, and M. W. Ohland, "I don't like thinking about this stuff": Black and brown student experiences in engineering education," presented at the Excellence Through Diversity, Minneapolis, MN: American Society for Engineering Education, 2022. [Online]. Available: <https://peer.asee.org/41397>
- [74] S. Masta, D. Dickerson, A. L. Pawley, and M. W. Ohland, "The minimization of microaggressions in engineering education," presented at the 2022 CoNECD (Collaborative Network for Engineering & Computing Diversity), New Orleans, LA, 2022. [Online]. Available: <https://peer.asee.org/39145>
- [75] Rodríguez-Simmonds, A. Godwin, N. G. Pearson, T. G. Langus, and A. Kim, "Building inclusion in engineering teaming practices," *Stud. Eng. Educ.*, in press 2023.
- [76] H. K. Ro and K. I. Loya, "The effect of gender and race intersectionality on student learning outcomes in engineering," *Rev. High. Educ.*, vol. 38, no. 3, pp. 359–396, 2015, doi: 10.1353/rhe.2015.0014.
- [77] A. L. Pawley, "Shifting the 'Default': The case for making diversity the expected condition for engineering education and making whiteness and maleness visible," *J. Eng. Educ.*, vol. 106, no. 4, pp. 531–533, Oct. 2017, doi: 10.1002/jee.20181.