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Perceived Benefits of a STEM Intervention Program and Engineering Self-Efficacy: A Multi-Method Investigation*

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This study explored how students in an intervention program for underrepresented populations pursuing engineering in a U.S. university perceived the program's benefits and the relationships of those perceptions with participants' engineering self-efficacy in their first year of undergraduate study. Data came from a multi-method, longitudinal study of the U-ENGIN program situated in a highly selective research university in the U.S. Midwest. Participants included 147 U-ENGIN students and 78 College of Engineering comparison group members for a total sample size of 225 over a time period of four years. Results are reported for Students of Color, White students, and a comparison group of students that did not participate in the intervention program. In this study, Students of Color refers to African Americans, American Indians or Native Americans, Asian Americans or Pacific Islanders, Latinx, and any non-White race specified by the respondents. Findings indicate the program contributed to increased engineering self-efficacy for Students of Color, while support networks cultivated through the program and exposure to engineering prerequisites prepared them for their academic experience. The study provides insight into how elements of a STEM intervention program can contribute to the self-efficacy of underrepresented students and potentially impact student success.

Keywords: engineering self-efficacy; STEM Intervention Programs; Students of Color

1. Introduction

Science, technology, engineering, and mathematics intervention programs (SIPs) were initially created to broaden the participation of underrepresented students in STEM fields [1]. These programs were also created to serve target populations in their institutional contexts. Such programs have proliferated at research institutions for various reasons including the desire to replicate successful programs, funding opportunities in support of such efforts, and external mandates for institutional interventions to address underrepresented students' access, retention, and matriculation in STEM fields [2]. Though varying in their mission statements and target populations, these programs have similar elements, including academic advising, tutoring, community building, mentoring, and professional development opportunities.

In this paper we investigate the effectiveness of an SIP situated in a predominantly White, research intensive U.S. university – the U-ENGIN[1] program. U-ENGIN, established in 2008, is a co-educational, cohort-based intervention program specifically focused on providing academic and social support for engineering students from diverse backgrounds during their first and second year of college. U-ENGIN's emergence came during a pivotal point in the institution's history. Only five years prior, in June of 2003, the U.S. Supreme Court upheld the use of affirmative action regarding university admissions processes in the Grutter v. Bollinger and Gratz v. Bollinger cases [3]. However, in response to this landmark ruling, voters in the state constitutionally banned the use of affirmative action with respect to public employment, education, and contracting. Thus, the establishment of the U-ENGIN program represents an institutional intervention with an explicit mission to increase the diversity of students enrolled in and graduating from engineering programs.

U-ENGIN specifically invites the participation of students who are of lower socioeconomic status, first generation, and/or traditionally underrepresented in U.S. engineering programs by race or gender with the aim of preparing these students for careers or graduate education in engineering fields. Taking an integrated and holistic approach, the U-ENGIN program provides participants with a rigorous summer transition program experience, one-on-one academic coaching with a U-ENGIN staff member, academic and professional development workshops, peer mentoring, and a stipend upon successful completion of programmatic

[1] Pseudonym used.

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requirements during the first year. Such requirements include attending weekly supplemental instruction sessions for mathematics and study groups for science courses, appointments with engineering advising center counselors, and monthly attendance at "family meetings," which are sessions designed for students to continue to build community and learn about various academic and professional resources.

Uniquely, U-ENGIN serves academically high achieving students from diverse backgrounds. Though high-achieving, Students of Color – those who are categorized as racially or ethnically underrepresented in the U.S. – participating in this program may still contend with experiences of marginalization in their academic contexts which may deter them from their educational pursuits. Students of Color are reported to encounter more frequent institutional barriers and challenges to persistence in college than White students, such as experiencing negative campus climate and racial discrimination [4, 5]. Within engineering especially, Students of Color are more likely to leave engineering as a major and as a profession [6]. Students of color, in particular, are compelled to navigate marginalization [7]. Johnson's study on Black and Latinx students in engineering found that ethnoracial marginalization caused many students to have a decreased sense of belonging and lower self-esteem. Particularly for Women of Color in engineering, both racial and gendered microaggressions can contribute to increased anxiety and depression [8]. Therefore, identifying experiences that contribute to academic persistence is important in supporting the retention of Students of Color in engineering programs and professional careers.

Using a multi method approach, we specifically sought to understand if and how participation in U-ENGIN influenced the engineering self-efficacy of Students of Color during their first year of college. To answer this question, we investigated how the engineering self-efficacy of Students of Color and White students participating in U-ENGIN compared and changed over time in relation to a comparison group of peers. Further, we examined the relationship between participation in U-ENGIN and students' engineering self-efficacy, along with associations between students' reported perceptions of program benefits and their end-of-first-year engineering self-efficacy. Finally, we analyzed interviews conducted with U-ENGIN students at the end of the first year to better understand how participating in the program influenced Students of Color engineering self-efficacy specifically.

This study valuably contributes to extant literature in various ways. First, this study focuses on engineering – a discipline that has not succeeded in recruiting Students of Color in proportion to their representation in the U.S. population – thus contributing to the marginalization of such students. The U-ENGIN program thus provides a useful case for examining how such SIPs work in a single discipline rather than studying across disciplines which can potentially have a masking effect due to differences of student compositions and histories of inclusion and exclusion. Second, we use a discipline-specific measure of self-efficacy that is also related to the educational outcomes promoted by the program. Third, this study includes a comparison group of similarly high achieving students in engineering to help determine the relationship between U-ENGIN participation and students' engineering self-efficacy. The inclusion of a comparison group in a study of an SIP is uncommon and with this addition we aim to better understand the U-ENGIN program's influence on participants' efficaciousness. Finally, our multi-method approach includes analysis of student interview data to deepen understanding of how students believe this intervention program supports their self-efficacy.

2. STEM Intervention Programs and Self-Efficacy

Students with high self-efficacy – or confidence in their ability to complete a task – are more likely to be academically motivated and are therefore more likely to persist toward graduation [9]. In contrast, students with lower self-efficacy may be vulnerable to discontinuing their academic pursuits. Though high-achieving students may enter universities with high self-efficacy, it is possible that experiences they encounter while in college may negatively affect their self-efficacy, particularly in the STEM fields [10]. For instance, Students of Color in predominantly White institutions, may contend with institutional barriers such as racism and discrimination that contribute to lower self-efficacy and therefore lower persistence in college [11, 12]. For example, in a study of Black women in engineering in U.S. institutions, Blosser [13] found that these women were often excluded and ignored which caused them to doubt their abilities and feel isolated.

In general, SIPs seek to help students successfully transition into their new collegiate environments academically and socially. Salas-Morera et al. [14] studied a program that supported students in their transition from high school to college in Spain and found that integrating peer mentoring, providing academic resources, and providing strategies for studying improved the academic performance of first year students compared to those that were not a part of the programs. These program may increase students' sense that they can succeed in a demanding academic program. In this regard, Lourens and Pannell [15] found that a co-curricular intervention for women in engineering in South Africa slightly improved women's self-efficacy in their first year. Ultimately, SIPs hope to increase degree completion but evidence is sparse. In Liberia, Rimer et al. [16] found that co-curricular programming that focused on teaching students' soft skills such as working in groups, presentation and communication skills, and study skills increased the commitment of students to continue pursuing an engineering degree. Given the challenges of longitudinal study, it remains important to study how SIPs may aid retention throughout a student's academic program by helping them navigate the challenges they experience in their academic programs.

Several scholars argue that lack of exposure in K-12 education to advanced math and science courses and difficulty building cultural community can negatively influence the academic self-efficacy of historically underrepresented students [12, 19, 20]. Yet, shifting the focus from the student to the educational environment, Strayhorn [12] argued that marginalized students from historically underrepresented backgrounds (e.g., Latinx, African-Americans, and Native Americans) may have lower academic self-efficacy due to a lack of support in the STEM university environment. In U.S. programs, strategies for improving SIP participants' academic self-efficacy include, but are not limited to, academic advising, faculty mentorship, tutoring, internship opportunities, and career and skill development. Past research on university SIPs also reveals that Latinx and African American students benefit from a supportive network that can help increase academic self-efficacy and lead to positive college outcomes such as retention and persistence [17, 19, 20].

Some SIPs provide summer bridge experiences to help prepare new undergraduates, academically and socially, for their first year in college [12]. These bridge programs intentionally engage participants in community building with a cohort while introducing students to the rigor of STEM coursework [21]. This experience is expected to help students feel connected to the university community and contribute to student persistence [22]. A quantitative study on five cohorts in an SIP (n = 129) found that students identified the SIP as a "counterspace" that helped mitigate negative racial and gendered aspects of STEM culture [23]. As a result, the participants indicated having a sense of belonging within the SIP compared to their STEM majors. In a study of African American students participating in a U.S. STEM summer bridge program, Johnson [17] found that most students entered the program with high levels of academic self-efficacy and their sense of efficacy remained high at the conclusion of the summer program. Johnson suggested early exposure to the rigor of STEM coursework, along with the acquisition of study skills such as time management and study methods, contributed to increased academic self-efficacy during the school year. In his study of summer bridge components, Strayhorn [12] found that participation in a summer bridge program in a U.S. university positively affected the academic skill development of Students of Color, such as comfort with reading comprehension and asking questions in class. Strayhorn also found that students' positive beliefs in their academic capabilities, a measure of academic self-efficacy, positively predicted their first semester GPA. None of the previous studies discussed, however, included a comparison group of Students of Color, which the present study offers.

Research has also demonstrated that the development of supportive networks through SIPs that focus on building community and strengthening academic skills can boost the academic self-efficacy of Students of Color [18]. At the University of Alabama (UA), the S-STEM program focuses on creating a culture of support, improving students' math skills, and providing financial resources to students who are financially and academically at-risk [21]. The UA S-STEM program provides scholarships to support student financial need, improves math skills through a bridge program from freshman to sophomore year, and focuses on cohort style experiences through field trips, peer mentoring, special study spaces, faculty advisors, and study sessions. Findings indicated that students who participated in the UA S-STEM program had higher retention and graduation rates than the comparison group. A recent study on an SIP found that key components of the program – which included providing content knowledge through summer bridge, recitation sessions to improve student skills in math and chemistry, supporting academic behaviors such as developing study skills, improving college literacy and time management, and developing cognitive strategies to approach STEM work – helped underrepresented students feel more prepared for their STEM coursework and for college [24].

Additional research indicates that the Meyerhoff Scholars Program (MSP) at the University of Maryland – which focuses on providing participants with academic and social support, along with skill development, and intrusive advising – has had long-term effects on persistence and retention of high-achieving graduate Students of Color

[18]. These program elements increased students' research self-efficacy leading to persistence in STEM. Maton et al. [18] also found that participants' perceptions of program benefits were associated with a sense of community, science identity, and research self-efficacy. Additionally, student program participants were more likely than comparison group members to persist and achieve doctoral degrees in STEM. The researchers attributed the development of a community of STEM students as being the primary factor influencing both science identity and research self-efficacy. Programs like the MSP can potentially contribute to the self-efficacy of Students of Color since one of the main barriers for Students of Color entering the STEM academic environment is perceptions of a lack of support and inclusion [25].

Although research demonstrates that there is a connection between academic and research self-efficacy and SIPs [17–20], the question of whether such programs can sustain self-efficacy in a particular major – such as engineering – have not been conducted, especially at the undergraduate level. Though Maton et al.'s [18] study demonstrated a relationship between students' perceptions of program benefits and research self-efficacy, it was conducted at the graduate level. These findings may be less relevant for engineering undergraduates who may be more likely to pursue careers in industry upon graduation rather than doctoral degrees. In this study we sought to understand if and how undergraduate Students of Color's participation in U-ENGIN influenced a domain-specific measure of self-efficacy – engineering self-efficacy (students' confidence in their engineering abilities) – during the first year of their undergraduate program. Our goal is to provide insight into how SIPs such as U-ENGIN contribute to the development of more self-efficacious Students of Color in engineering, which can potentially contribute to their persistence and retention in their majors.

3. Conceptual Framework

Broadly, SIPs tend to focus on developing students' self-efficacy by fostering a sense of community and connecting students to multiple resources including academic assistance, relationships with faculty, and career guidance. Bandura's explanation of sources that impact an individual's self-efficacy indicates that a STEM intervention program like U-ENGIN may positively influence the self-efficacy of its participants.

According to Bandura [26], self-efficacy is influenced by four sources: mastery experiences, vicarious experience, verbal and social persuasion, and emotional and physiological states. A person's efficaciousness can affect the amount of time and energy expended on a task, and his or her ability to persist despite barriers. Accordingly, a student with high engineering self-efficacy is more likely to persist toward achieving a degree in engineering despite challenges encountered.

Mastery experiences involve modeled or guided assistance that helps a person acquire the skill needed to overcome stressful experiences. This includes changing the environment so that the individual can feel less threatened in the beginning as they learn coping mechanisms. For example, a summer bridge program that provides participants with academic skill development and college-level coursework could foster mastery experiences for students. Vicarious experiences refer to witnessing another person with a shared identity successfully overcome obstacles, which encourages the observer to do the same. An SIP with a peer mentoring component which matches program participants with advanced students who role model how to persevere through academic challenges can provide vicarious experiences. Bandura further theorized that verbal and social persuasion, such as telling a person that he or she can accomplish a task and has the skills to do so, would influence self-efficacy in a domain. Programs that engage in career coaching by which students are "coached" through struggles with academic or career-related tasks represent verbal and social persuasions. Finally, an individual's emotional and physiological state can determine whether they develop anxiety based on aptitude, which can contribute to low self-efficacy. Bandura explains that to increase self-efficacy through this source, the person must be influenced to believe that they can accomplish the task and develop an increased perception of self-confidence. In an SIP, such influencing and confidence-building could occur in relationships fostered between faculty members and students.

4. Methodology

In this study, we first examined how the engineering self-efficacy of Students of Color and White students participating in U-ENGIN compared and changed over time in relation to their comparison group peers, taking into account participants' prior STEM courses in high school and academic achievement. We also explored the relationship between students' perceptions of the U-ENGIN program's benefits and engineering self-efficacy after their first year in college. We hypothesized that the perceived benefits of the U-ENGIN program (i.e., students' ratings of the helpfulness of the U-ENGIN program components) would be positively related to their engineering self-efficacy. To

Table 1. Categorical Variable Frequencies for U-ENGIN Participants

Variable		N	%
Sex	Female	70	47.62
	Male	77	52.38
Race	People of Color	84	57.14
	White	63	42.86
High School GPA	4.0 or above	42	28.57
	Below 4.0	105	71.43
Calculus 1 in HS	Did have Calculus 1	125	85.03
	Did not have Calculus 1	22	14.97
Adv. Chemistry in HS	Did have Adv. Chemistry	93	63.27
	Did not have Adv. Chemistry	54	36.73
Adv. Physics in HS	Did have Adv. Physics	79	53.74
	Did not have Adv. Physics	68	46.26

Table 2. Categorical Variable Frequencies for College of Engineering Comparison Group Members

Variable		N	%
Sex	Female	36	46.15
	Male	42	53.85
Race	Students of Color	26	33.33
	White	52	66.67
High School GPA	4.0 or above	31	39.74
	Below 4.0	47	60.26
Calculus 1 in HS	Did have Calculus 1	76	97.44
	Did not have Calculus 1	2	2.56
Adv. Chemistry in HS	Did have Adv. Chemistry	58	74.36
	Did not have Adv. Chemistry	20	25.64
Adv. Physics in HS	Did have Adv. Physics	54	69.23
	Did not have Adv. Physics	24	30.77

better understand the relationships we identified, we analyzed interviews conducted with U-ENGIN students from two cohorts at the end of their first years at the university.

4.1 Quantitative Data

Data for this study come from a multi-method, longitudinal study of the U-ENGIN program at a public university located in the U.S. Midwest. For the quantitative analysis, data was collected from U-ENGIN cohort surveys (2013–2016) administered electronically through Qualtrics. U-ENGIN students were surveyed prior to their participation in the summer transition program, immediately following their participation in the summer program, at the end of their first year, and every subsequent year until graduation. Surveys were also administered to U-ENGIN comparison group members, who were students that were eligible for the program, but were either not selected, or declined the invitation to participate. For the purposes of this study, we examined U-ENGIN student responses prior to participating in the summer program to the end of their first year. Additionally, we examined the College of Engineering comparison group member responses from the post-summer program survey (the first point of contact for comparison group members) to the end of their first year of college. Pre-summer program response rates for the 2013, 2014, 2015, and 2016 U-ENGIN cohorts were 96.7% (58 students), 88.7% (55 students), 93.6% (58 students), and 100% (64 students), respectively. Post-summer program response rates were, respectively, 72.4%, (42 students), 88.7% (55 students), 98.4% (61 students), and 100% (64 students). Finally, end-of-first-year response rates were 62.1% (36 students), 71% (44 students), 74.2% (46 students), and 84.4% (54 students). For College of Engineering comparison group members, the total numbers of students who completed post-summer surveys for the 2013, 2014, 2015, and 2016 cohorts were, respectively, 20, 72, 57, and 71 students. The total numbers of students who completed end-of-first-year surveys for the 2014, 2015, and 2016 comparison group cohorts were 64, 57, and 58 students. No end-of-first-year survey was administered to the comparison group in 2013. Of the College of Engineering comparison group respondents, seventy-eight (78) students completed both post-summer and end-of-first-year surveys. The final samples for the analyses in this study included 147 U-ENGIN students (70 women and 77 men, 84 Students of Color and 63 White) and 78 College of Engineering Comparison Group members (36 women and 42 men; 26 Students of Color and 52 White) (Tables 1 and 2). In this study, a Student of Color refers to African Americans, American Indians or Native Americans, Asian Americans or Pacific Islanders, Latino/as, and any non-White race specified by the respondents. Sample limitations required that we examine the experiences of Students of Color as a group, rather than disaggregating the survey data further by race. Respondents with missing data on survey items of interest for this study were excluded from the analytical sample.

4.2 Quantitative Measures

For the quantitative analysis, the dependent variable of interest is students' end-of-first-year self-efficacy, which we measured as students' engineering major confidence. This is a continuous variable ranging from 1-5, with 5 being the highest rating a student could self-report (Strongly Disagree = 1, Strongly Agree = 5). Prior to this study, we performed an exploratory factor analysis on the engineering efficacy measure with student responses from the 2013 cohort; that analysis produced two distinct factors. For this study, we used one of these factors – the engineering major confidence factor –

Table 3. Items Included in the Engineering Major Confidence Measure

Engineering Major Confidence
I can succeed in an engineering major
I can complete the math requirements for most engineering majors
I can succeed in an engineering major while not having to give up participation in my outside interests
I can excel in an engineering major during the current academic year
I can succeed (earn either an A or B) in an advanced physics course
I can complete any engineering degree at this institution
I can succeed (earn either an A or B) in an advanced math course
I can complete the physics requirements for most engineering majors
I can complete the chemistry requirements for most engineering majors

which captures students' belief in their ability to succeed as an undergraduate majoring in engineering. The second factor pertained to students' confidence in their ability to succeed in the engineering profession, which was outside the scope for this study since our sample was limited to first-year students. Items in the engineering major confidence factor can be found in Table 3. The Cronbach's alpha for the engineering major confidence factor is 0.92, indicating high internal consistency. This factor was used for subsequent cohorts.

The independent variables related to student background for this study include sex, race, high school GPA, and advanced coursework in Calculus 1, Physics, or Chemistry taken in high school. Sex is measured dichotomously (0 = male, 1= female), as is race (0 = Person of Color, 1 = White). The high school GPA variable was also recoded as a dichotomous variable to indicate whether students earned above or below a 4.0 GPA (0 is $>$ 4.0 GPA, 1 is $\leq$ 4.0 GPA). This decision reflects the lack of variation in the high school grades of this high-achieving student sample. The advanced math or science courses taken in high school were also measured dichotomously. For instance, if a student took Calculus 1 in high school they received a 1, if they did not take that class they received a 0. The variables for course taking in advanced Physics and Chemistry, respectively, were recoded in the same fashion.

Students also responded to survey questions asking how beneficial they found specific components of the U-ENGIN program (Not at all helpful = 1 to Extremely helpful = 5). These components consist of family meetings, peer mentor meetings, academic coaching, engineering advising center appointments, college of engineering academic support/tutoring, academic and professional skill development sessions, math supplemental instruction sessions, and science course study groups. For all cohorts, 2013-2016, we took the numerical average of a student's program component helpfulness ratings as reported at the end-of-year-one survey to develop the continuous U-ENGIN program benefit variable, a single rating of a student's perceived benefit of participating in U-ENGIN.

4.3 Quantitative Analyses

4.3.1 T-Tests: Comparing Engineering Self-Efficacy of U-ENGIN Participants and Comparison Group Members Over Time by Race

We first conducted t-tests with U-ENGIN participants and comparison group members to determine if the mean engineering self-efficacy of Students of Color and White students changed over time, respectively. We also explored if there were differences between comparison group students and U-ENGIN students over time by race. We conducted additional t-tests with the U-ENGIN students only to determine if there were differences between the engineering self-efficacy ratings of U-ENGIN Students of Color and White U-ENGIN students. Further, we investigated whether U-ENGIN Students of Color and White students' engineering self-efficacy changed over time.

4.3.2 OLS Analysis 1: Relationship Between Participation in U-ENGIN and End-of-First-Year Engineering Self-Efficacy

Next, we performed ordinary least squares linear regressions to determine if (1) U-ENGIN participation influenced students' end-of-first-year engineering self-efficacy and (2) if there was a relationship between students' perceived benefit ratings of the U-ENGIN program and their engineering self-efficacy as reported at the end of their first year in the program. For the first regression, the sample consisted of U-ENGIN participants and College of Engineering comparison group members (i.e., students that were eligible for U-ENGIN, but were either not selected to participate or declined the invitation to participate in the program). The independent variable – a measure for whether the student was a U-ENGIN participant, or a comparison group member – was included in the model. Control variables in the model included: sex, race, high school GPA, advanced high school course taking in either Calculus 1, Chemistry, or Physics, and students' engineering self-efficacy as reported at the first time surveyed (Table 4). We also examined the frequencies of the individual helpfulness ratings of each program component to better understand what aspects of the U-ENGIN program participants found especially useful (Table 5).

Table 4. Estimated Coefficients and Standard Errors of OLS Regression of End-of-Year Engineering Self-Efficacy on Select Independent Variables, Including U-ENGIN Participation

Variables	(S.E.)
Female	–0.04 (0.08)
White	–0.03 (0.09)
High School GPA	–0.20 (0.09)*
Calculus 1 HS	–0.01 (0.14)
Adv. Chemistry HS	0.02 (0.09)
Adv. Physics HS	0.07 (0.09)
First Reported Engineering Self-Efficacy	0.53 (0.07)***
U-ENGIN Participation	0.10 (0.09)
r^2	0.23

Note: N = 194; p < * 0.05, ** 0.01, *** 0.001.

4.3.3 OLS Analysis 2: Relationship Between Students' Perceived Benefits of U-ENGIN Participation and End-of-Year Engineering Self-Efficacy

A second set of regressions examined the relationship between students' perceived benefits of the U-ENGIN program and end-of-first-year engineering self-efficacy. In Model 1, with end-of-year engineering self-efficacy as the outcome variable, we controlled for student background variables, which included sex, race, high school GPA, and advanced high school course taking in Calculus 1, Chemistry, or Physics. In the second model, a control for students' engineering self-efficacy as reported in the pre-summer transition program survey was added. Finally, in the third model, the independent variable – an index variable capturing students' perceived benefits of the U-ENGIN program – was included along with the variables from Models 1 and 2 (Table 6).

4.4 Qualitative Data

Qualitative data came from individual end-of-first year interviews conducted with subsets of Students of Color from the 2013 and 2015 U-ENGIN cohorts. We focus specifically on the data from the 2013 and 2015 cohorts (the 2014 cohort participated only in focus groups; the 2016 cohort was not interviewed as per the study timeline). Interview questions focused on students' academic and co-curricular experiences, and their educational and career plans for the future. Interviews ranged from approximately 30 minutes to 60 minutes. All interviews were transcribed verbatim.

4.5 Qualitative Analysis

After conducting the quantitative analyses, we analyzed the qualitative data of Students of Color to understand whether and how components of the U-ENGIN program that were not captured in the program benefits measure might contribute to the engineering self-efficacy of U-ENGIN students. Members of the research team divided into sub-teams to code the interview data using the codebook developed by the team during the course of the study. For each interview transcript, two team members individually coded the transcript and then met to reconcile any differences in coding assignments. Coding decisions were then entered into NVivo.

For this study, the authors performed an iterative and inductive analysis of transcripts and interpretations of findings [27]. Utilizing NVivo 11 software, query reports of specific codes pertaining to U-ENGIN participants' college expectations, relationships with peers, study strategies, time management

Table 5. U-ENGIN Students' Helpfulness Ratings of Program Component

Program Component	Percentage of Very Helpful Ratings (4)	Percentage of Extremely Helpful Ratings (5)	Combined Total	Potential Self-Efficacy Category
U-ENGIN Math Supplemental Instruction	41.54	40	81.54	Mastery Experience
U-ENGIN One-on-One Academic Coaching	41.79	38.81	80.6	Verbal and Social Persuasions
SLC peer-Led Study Group for Chemistry	31.75	41.27	73.02	Mastery Experience
COE-Based Academic Support/Tutoring (ELC)	30.19	22.64	52.83	Mastery Experience
Engineering Academic Advising (EAC Advising)	28.36	22.39	50.75	Verbal and Social Persuasions
Mentor/Protege Meetings	31.34	14.93	46.27	Vicarious Experience
Scholar Power Forums	34.85	10.61	45.46	Mastery Experience
SLC Peer-Led Study Group for other Science Course (i.e. not Chemistry)	21.82	23.64	45.46	Mastery Experience
Academic Skills Follow-up Sessions	36.92	7.69	44.61	Verbal and Social Persuasions & Mastery Experience
Family Meeting (Social Support)	32.47	5.19	37.66	Verbal and Social Persuasions & Vicarious Experience
Family Meeting	19.4	8.96	28.36	Verbal and Social Persuasions & Vicarious Experience

Table 6. Estimated Coefficients and Standard Errors of OLS Regressions of End-of-Year Engineering Self-Efficacy on Select Independent Variables, Including Perceived Program Benefits for U-ENGIN Participants

Variables	Model 1 (S.E.)	Model 2 (S.E.)	Model 3 (S.E.)
Female	–0.10 (0.10)	–0.03 (0.09)	–0.03 (0.09)
White	–0.03 (0.11)	0.01 (0.10)	0.00 (0.09)
High School GPA	–0.13 (0.11)	–0.21 (0.11)*	–0.16 (0.10)
Calculus 1 HS	0.08 (0.14)	–0.05 (0.14)	–0.04 (0.13)
Adv. Chemistry HS	0.09 (0.11)	–0.02 (0.10)	0.01 (0.10)
Adv. Physics HS	0.09 (0.11)	0.10 (0.10)	0.10 (0.10)
Pre-Summer Engineering Self-Efficacy		0.46 (0.09)***	0.49 (0.09)***
U-ENGIN Program Benefits			0.24 (0.06)***
r^2	0.04	0.19	0.27

Note: N = 147; p < *0.05, **0.01, ***0.001.

skills, along with engagement in U-ENGIN programmatic elements including: family meetings, academic and professional skill building sessions, academic coaching, supplemental instruction, and study groups were created and analyzed. The coding reports were reviewed independently by each author and later discussed comprehensively to reach consensus regarding emergent themes. Our findings focus on the interviews with the Students of Color as we were interested in understanding how the U-ENGIN program contributed to the self-efficacy of Students of Color in engineering.

5. Limitations

The analyses performed in this study were focused on data collected during the students' first year; yet, the U-ENGIN program provides formal support until the end of the students' second year. Further research examining the relationship between perceived program benefits and students' engineering self-efficacy throughout the duration of the U-ENGIN program is warranted. Additionally, we used an index variable to capture U-ENGIN students' perceived benefits of participation since data collected regarding the program elements varied slightly between cohorts. However, programmatic elements that were included in the index variable have potential linkages to Bandura's theory of self-efficacy [26], such as academic coaching possibly being connected to verbal persuasion. Lastly, in the qualitative interviews, students were not asked explicitly about their racialized experiences in college or the U-ENGIN program. In future research, U-ENGIN participants' racialized experiences should be explored further to add nuance to students' discussion of the program and their campus life. Our quantitative data was also limited in that we could not disaggregate the data to measure the association between SIP program elements and engineering self-efficacy on different racial categories. Further research should examine the impact of STEM intervention programs on specific racial groups. Findings from this study should not be generalized beyond the U-ENGIN program; however, programs of similar design that are developed to serve comparable student populations might expect similar results.

6. Findings

Findings from the quantitative analyses revealed that at the conclusion of the summer transition program, U-ENGIN Students of Color had significantly higher engineering self-efficacy than their comparison group counterparts who did not participate. By the end of the first year, however, there were no significant differences between groups. Additionally, there was no significant difference in mean engineering self-efficacy between Students of Color and White students in the U-ENGIN program throughout the first year. We did, however, observe a significant increase in engineering self-efficacy for Students of Color between the pre-summer program survey and the post-summer program survey. Although Students of Color experienced a decline in engineering self-efficacy by the end of their first year, it was not significantly different from their initial reports of confidence prior to the summer transition program. In addition, participation in U-ENGIN did not appear to predict students' end-of-year-engineering self-efficacy. However, the measure of U-ENGIN students' perceived benefits of the U-ENGIN program was positively associated with an increase in engineering self-efficacy at the end of the first year. A more detailed description of the results follows.

6.1 Comparison Group Students' Mean Engineering Self-Efficacy Over Time

To begin understanding the potential influence of the U-ENGIN program on participants' engineer-

Table 7. Comparison of the Mean Engineering Self-Efficacy Scores from Post-Summer to End-of-Year for Comparison Group Students of Color and White Students Respectively

People of Color					White				
Post-Summer		End-of-Year		Difference in Means	Post-Summer		End-of-Year		Difference in Means
N	M (S.D.)	N	M (S.D.)		N	M (S.D.)	N	M (S.D.)	
26	3.88 (0.58)	26	3.95 (0.53)	–0.07	52	3.90 (0.56)	52	3.80 (0.75)	0.10

ing self-efficacy, we first examined if and how engineering self-efficacy for the comparison group only changed over time. For Students of Color in the comparison group, there were no significant differences in mean engineering self-efficacy from the summer prior to the academic year to the end of the academic year. Similarly, White students in the comparison group experienced no significant differences in their mean engineering self-efficacy during that time frame (Table 7). Yet, we note that the mean self-efficacy scores for members of the comparison group are relatively high: 3.95 on a five-point scale for Students of Color and 3.80 for White students. This is not surprising as both comparison group students and U-ENGIN students at this highly selective university are high achieving and may be subject to other supports within and outside of the university. Nonetheless, there is evidence that a relationship may exist between participation in U-ENGIN and engineering self-efficacy.

6.2 Comparing U-ENGIN and Comparison Group Students' Mean Self-Efficacy

T-tests comparing the mean engineering self-efficacy of U-ENGIN Students of Color and comparison group Students of Color demonstrated that in the summer prior to their first year – that is, immediately following U-ENGIN students' participation in the summer transition program – U-ENGIN Students of Color had significantly higher engineering self-efficacy than their comparison group counterparts (Table 8). However, by the end of the first year, U-ENGIN and comparison group Students of Color did not differ significantly in engineering self-efficacy. For White students, there was not a significant difference between U-ENGIN participants or comparison group members at either the summer prior to first year or the end of first year (See Table 9). Since we found a significant difference in mean engineering self-efficacy between U-ENGIN and comparison group Students of Color at the end of the summer transition program, we performed a regression to determine whether participation in U-ENGIN was associated with end-of-first-year engineering self-efficacy.

6.3 Examining the Relationship Between Students' Participation in the U-ENGIN Program and End-of-First-Year Engineering Self-Efficacy

Our first regression examined students' first-year engineering self-efficacy as related to their initial major confidence, U-ENGIN participation, demographic characteristics, and high school course taking. We found U-ENGIN participation was not significantly related to students' end-of-year engineering self-efficacy controlling for all other factors (see Table 4). Having a lower high school GPA was negatively associated with engineering self-efficacy. Though participation in U-ENGIN was not significantly associated with students' end-of-first-year engineering self-efficacy in relation to their comparison group peers, it is possible that there is variation within U-ENGIN students' experiences that may be obscured at the level of program participation. To determine whether there

Table 8. Comparison of the Mean Engineering Self-Efficacy Scores of Students of Color in the Comparison Group and U-ENGIN Program at Post-Summer and End-of-Year

Time Point	Comparison Group		U-ENGIN Students		Difference in Means
	N	M (S.D.)	N	M (S.D.)	
Post-Summer	26	3.88 (0.58)	48	4.31 (0.52)	–0.43***
End-of-Year	26	3.95 (0.53)	51	4.01 (0.70)	–0.06

Note: p < *0.05, **0.01, ***0.001.

Table 9. Comparison of the Mean Engineering Self-Efficacy Scores of White Students in the Comparison Group and U-ENGIN Program at Post-Summer and End-of-Year

Time Point	Comparison Group		U-ENGIN Students		Difference in Means
	N	M (S.D.)	N	M (S.D.)	
Post-Summer	52	3.90 (0.56)	60	4.07 (0.54)	–0.17
End-of-Year	52	3.80 (0.75)	65	3.97 (0.52)	–0.17

were differences between the mean engineering self-efficacy of U-ENGIN Students of Color and White students, we performed additional t-tests.

6.4 Comparing U-ENGIN Students of Color and White Students' Mean Engineering Self-Efficacy

We conducted t-tests comparing Students of Color and White students' engineering self-efficacy ratings prior to the summer transition program (Time 1), after the summer program (Time 2), and at the end of the first year (Time 3) (see Table 10). T-Tests comparing Students of Color and White students' mean engineering self-efficacy at Time 1 revealed no statistically significant difference in means. Similarly, there was no significant difference between Students of Color and White students' mean engineering self-efficacy at Time 2 or Time 3. This finding demonstrates that Students of Color and White Students' in the U-ENGIN program maintained comparable levels of engineering self-efficacy during their first year in the College of Engineering. Moreover, Students of Color and White students' mean engineering self-efficacy levels remained relatively high by the end of their first year in college (4.01 for Students of Color and 3.95 for White students).

6.5 Examining U-ENGIN Students of Color and White Students' Mean Engineering Self-Efficacy Over Time

To determine whether or not U-ENGIN Students of Color and White students' engineering self-efficacy changed over time, t-tests were performed to compare students' mean engineering self-efficacy ratings from Time 1 to Time 2, Time 2 to Time 3, and Time 1 to Time 3 (Table 11). The t-tests for Students of Color and White students were conducted separately to determine if there were differences over time by race. For Students of Color, t-tests comparing mean engineering self-efficacy at Time 1 and Time 2 revealed a significant difference in means. The mean engineering self-efficacy for Students of Color after participating in the summer transition program was significantly higher than prior to the summer transition program.

Additionally, students' mean engineering self-efficacy at Time 3 was significantly lower than their confidence at Time 2. In sum, for U-ENGIN Students of Color, mean engineering self-efficacy decreased significantly after completing the summer transition program to the end of the first year, but the difference in mean engineering self-efficacy between Time 1 and Time 3 was not statistically significant. Thus, despite the decrease in mean engineering self-efficacy by the end of the first year, the difference between students' confidence prior to the summer program and the end of the first year is negligible. These findings demonstrate that for Students of Color, there is an increase in engineering self-efficacy after participating in the U-ENGIN summer transition program. Although students experience a decline in their confidence by the end of the year, it remains comparable to the level reported prior to the summer program.

White students did not appear to experience the same increase in engineering self-efficacy after participating in the U-ENGIN summer program compared to Students of Color. For White students, the difference in means from Time 1 to Time 2 was not significant. However, similar to Students of Color, White students' mean engineering self-efficacy was significantly lower at the end of the first year

Table 10. Comparison of the Mean Engineering Self-Efficacy Scores at Each Time Point for U-ENGIN Students of Color and White Students Respectively

	Students of Color		**White Students**		**Difference in Means**
Engineering Self-Efficacy	**N**	**M (S.D.)**	**N**	**M (S.D.)**	
Pre-Summer Program	84	4.07 (0.52)	63	3.97 (0.57)	0.09
Post-Summer Program	74	4.18 (0.56)	60	4.06 (0.55)	0.13
End-of-Year	84	4.01 (0.64)	63	3.95 (0.56)	0.06

Table 11. Comparison of Engineering Self-Efficacy Means and Standard Deviations over Time for U-ENGIN Students of Color and White U-ENGIN Students

Students of Color					**White Students**				
Pre-Summer		**Post-Summer**		**Difference in Means**	**Pre-Summer**		**Post-Summer**		**Difference in Means**
N	**M (S.D.)**	**N**	**M (S.D.)**		**N**	**M (S.D.)**	**N**	**M (S.D.)**	
74	4.06 (0.53)	74	4.19 (0.56)	-0.13***	60	3.96 (0.58)	60	4.06 (0.55)	-0.10
Pre-Summer		End-of-Year			Pre-Summer		End-of-Year		
84	4.07 (0.52)	84	4.01 (0.64)	0.06	63	3.97 (0.57)	63	3.95 (0.56)	0.03
Post-Summer		End-of-Year			Post-Summer		End-of-Year		
74	4.19 (0.56)	74	3.99 (0.66)	0.20**	60	4.06 (0.55)	60	3.92 (0.56)	0.14*

compared to after completing the summer transition program. Additionally, the difference in means between White Students mean engineering self-efficacy between Time 1 and Time 3 was not statistically significant. Therefore, White students' engineering self-efficacy at the end of their first year of college is similar to their confidence levels prior to participating in the U-ENGIN summer transition program. To better understand the factors that could contribute to differences in students' reported engineering self-efficacy at different time points we conducted an ordinary least squares regression with U-ENGIN students only, to determine if there was a relationship between students' perceived benefits of the U-ENGIN program and their end-of-first-year engineering self-efficacy.

6.6 Examining the Relationship Between Students' Perceived Benefits of U-ENGIN Participation and End-of-Year Engineering Self-Efficacy

In Model 1, controlling for sex, race, high school GPA, and advanced high school course taking in Calculus 1, Chemistry, or Physics, none of the controls were significantly related to end-of-first-year engineering self-efficacy for U-ENGIN participants (Table 6). However, in Model 2, with the addition of students' pre-summer program engineering self-efficacy, students' confidence prior to the summer transition program had a positive significant relationship with end-of-year engineering self-efficacy; in addition, having a lower high school GPA had a significant negative association with engineering self-efficacy. In Model 3, which includes students' perceived benefits of participating in the U-ENGIN program, high school GPA was no longer significant, yet students' pre-summer transition program engineering self-efficacy remained significant and the measure of perceived program benefits was positively associated with end-of-first-year engineering self-efficacy at the $p < 0.001$ level.

Results from Model 3 suggest that U-ENGIN students' perceptions of U-ENGIN's helpfulness could be influencing engineering self-efficacy. The measure of students' perceived program benefits is comprised of students' helpfulness ratings of formal U-ENGIN program elements such as family meetings, coaching, peer-mentoring, and academic tutoring; however, surveys did not assess the potential contribution of informal aspects of the program, such as relationships with cohort-mates, which might also influence students' engineering self-efficacy. Further, although perceiving U-ENGIN to be beneficial has a positive relationship with end-of-first-year engineering self-efficacy, it is unclear *how* students are actually engaging in the program throughout the academic year, which could contribute to their perceptions of its benefit. To better understand what aspects of the U-ENGIN program participants found especially useful, we conducted a frequency analysis of U-ENGIN participants' helpfulness ratings of each program component (Table 5). We found the highest rated components (i.e., rated very helpful or extremely helpful by more than 50 percent of participants) were the following: math supplemental instruction sessions (81.54%), academic coaching (80.60%), science course study groups (73.02%), college of engineering academic support/tutoring (52.83%), and engineering advising center appointments (50.75%). Though the frequency analysis helped determine which aspects of the U-ENGIN program participants found most useful, we recognize that there is still much to learn about how exactly the U-ENGIN program supports its students formally and informally. Thus, qualitative interviews with U-ENGIN participants provided additional insight into elements of the U-ENGIN program, including informal or social elements of program participation that appeared to contribute to their engineering self-efficacy at the end of their first year.

7. Qualitative Results

Findings from the qualitative analysis of Student of Color experiences revealed two themes concerning how U-ENGIN positively contributed to participants' engineering self-efficacy: (1) exposure to and preparation for engineering rigor and (2) the cultivation of academic and social support networks. Interview data come from subsets of U-ENGIN participants from the 2013 and 2015 cohorts who responded to the invitation sent by the research team, therefore, the opinions and experiences described may not reflect those of all U-ENGIN participants.

7.1 Exposure and Preparation for Engineering Rigor

Our analysis produced a clear theme regarding the role of the program in contributing to students' major confidence: students reported that the academic components of U-ENGIN helped them feel prepared for the rigors of studying engineering. During the end-of-first-year interviews, U-ENGIN participants were asked about their expectations of the College of Engineering prior to enrollment. U-ENGIN participants were commonly concerned about the difficulty of courses and being adequately prepared to smoothly transition from high school to college. During the six-week summer transition program, U-ENGIN students took classes in mathematics, computer programming, and engineering concepts, taught by faculty, staff, and graduate student instructors hired by the U-ENGIN program. These instructors also taught courses at the university during the academic year. Since the summer courses provided through U-ENGIN are not credit bearing, U-ENGIN participants can focus on grasping the material and adjusting to their new academic environment.

After completing their first year in the College of Engineering, U-ENGIN participants explained that the summer program simulated the rigors of study during the academic year, which helped them feel more confident as they approached the fall semester. A Black man student explained:

> "The amount of work that we were putting in, or the amount of work that we were doing, was equivalent to 22 credit hours . . . So I didn't know that at the end, but when I hit my actual classes it was like I only did what I thought was expected of me coming out of U-ENGIN. And it was still exceeding what I needed to do for most of my classes and it worked really well so far. At least for the first semester and so far this semester, it's worked really well. It made a seamless transition into college."

For this student, the intensive academic preparation offered during the summer laid the foundation for a successful school year.

Regarding successfully managing the difficulty of engineering classes at the university, another Black man shared, "I learned through the program that it was something that I could do." By exposing U-ENGIN students to the College of Engineering curriculum during the summer, the program helped alleviate some of students' initial concerns about the difficulty of majoring in engineering, which helped bolster their confidence prior to the academic year. The engineering coursework offered by the program over the summer provided participants with mastery experiences, which helped students feel more efficacious approaching the academic year.

Transitioning from the summer to the academic year, U-ENGIN students were expected to fulfill certain programmatic requirements to receive a stipend by the end of the first year. According to the U-ENGIN participant agreement form, such program activities included attending study skill and professional development seminars, supplemental instruction sessions for mathematics, along with study groups for chemistry. U-ENGIN participants described the supplemental instruction sessions and the study groups required by the program as especially beneficial because these provided the opportunity to review class concepts and work through practice exam problems. Regarding supplemental instruction sessions for Calculus III, a Black man participant shared:

> "They just went through a practice exam or a couple questions for practice exams and they did step-by-step solutions for them. It was really helpful to have the step-by-step solutions so that when you're doing like problems – like you could draw parallels from the different steps which was really helpful for Calc-III."

Another Black man found that the study groups for Chemistry, required by U-ENGIN, were helpful by providing students with a more intimate space to ask questions and revisit course content covered in their larger lectures. This student commented:

> "Because it is a class of 400 people, so you can't really get that one-on-one with the teacher so the study group allowed me to be in a class with 15 other students [and] with a student that just recently took the class. We just go over problems. And then there is also discussion, which reiterates everything you learned in lecture so you're always – you're just learning everything you previously saw in lecture. You just go more in-depth so it really helped."

Multiple U-ENGIN participants shared that they would not have been aware of, or perhaps would not have attended the tutoring sessions and study groups, if it were not for the U-ENGIN requirement. According to a Latino participant, "The supplemental instructions are actually really helpful. I probably wouldn't have gotten to them had they not been necessary." Some U-ENGIN students found the supplemental instruction sessions and study groups so helpful that they voluntarily participated in tutorial services for additional courses beyond the U-ENGIN requirement. One Latina student said, "I signed up for one this semester in physics; it is not required for us to do it in physics but I did it anyway." Requiring U-ENGIN participants to utilize academic support services such as supplemental instruction, tutoring, and study groups helped equip students with the tools needed to achieve academically, which increased their confidence as they approached their coursework during the academic year.

7.2 Social and Academic Support Networks

Another theme from the U-ENGIN interviews was the importance of social and academic support networks fostered through program participation. Students consistently described the academic coaches provided through the U-ENGIN program as integral members of their support network at the university. One Black man shared, "They want us to come in and talk to them about like what's going on and things that they can help us with. You know it really seems like they care and I really appreciate that." A Latina student said,

> "[My coach] was the most influential person within U-ENGIN and maybe person within my first year. It was just good to have someone that you could rely on that

kind of had to talk to you and had to help you . . . So it was just nice to have someone to lean back on."

Though monthly meetings with academic coaches were required for U-ENGIN participants, students described their relationships with coaches in more personal terms, referring to their coaches as "mentors," "friends," and on occasion "parents." Further, U-ENGIN students discussed approaching their coaches with a variety of concerns, which were not limited to academics. A Latina student described her experience with the academic coaches, "It feels like we're pretty close with them and we can talk with them just about anything. I trust them all." U-ENGIN students also expressed feeling as though their coaches were genuinely invested in their success and wanted to support them as much as they could. A Black man commented:

> "[The coaches] were always there to answer any questions that I had or support me in any ways that I needed. And also carried on throughout the school year too. I would say that was a surprise that they really stayed connected and followed up with us to make sure everything was okay with our academics and things like that, just as far as planning courses. Like they were always there to help me like if there was ever a time that I needed help."

For U-ENGIN students, having academic coaches to consult for academic, personal, or professional advice gave students a touchstone at the university who they felt comfortable approaching when they needed assistance.

U-ENGIN participants also discussed the importance of peer relationships fostered through the program in helping students feel supported and confident as they embarked on their first year in the College of Engineering. Students described the establishment of social and academic peer support networks as a vital aspect of the U-ENGIN program. Furthermore, several students identified their participation in U-ENGIN as essential to their college adjustment. According to a Latina student:

> "Well because I'm a really shy person, doing U-ENGIN, I truly believe is one of the best decisions I've ever made. I met 59 other people and having those friends made it a lot easier because I didn't know anyone coming here . . . So this is my first real having to make friends experience and I was terrified. I know if I hadn't made them over the summer – I remember thinking during welcome week that there is no way I would have survived."

Students also described their relationships with other cohort members as being family-like in reference to the close-knit bonds they were able to achieve during the six-week summer program and the academic year. The program's emphasis on peer accountability and fostering relationships during the summer was reinforced during the academic year through monthly "family meetings" where students continued to build community and learn about helpful resources and opportunities. As a formal component of the U-ENGIN program, family meetings provided a structured opportunity for U-ENGIN participants to come together and reconnect during the academic year. An Asian woman commented, "I just think mostly, it is a good way to catch up with everyone again. Because you know the school year, everyone is really busy doing everything so it is nice to come together." A Black man described family meetings as an opportunity to form relationships with advanced students from previous U-ENGIN cohorts. Upon meeting U-ENGIN affiliated upperclassmen, he said, "I have more family and some of them are in my majors. Let me get to know them so they can help me and I can help them." For U-ENGIN students, considering their fellow participants as family members contributed to a sense of responsibility and trust, which motivated them to offer and receive help willingly.

As students entered their first year in the College of Engineering, they described feeling embedded within a strong community of U-ENGIN scholars past and present. Several participants mentioned the connections they made with other U-ENGIN students as one of the most valuable aspects of the program. A Black man participant shared, "with U-ENGIN they like forced us to get together, to get to know people. I feel like that greatly helped because now I have some lifelong friends."

Through the U-ENGIN program, first year students were also paired with peer mentors who were typically advanced students with similar academic interests as their protégés. U-ENGIN participants spoke of how much they valued having peer role models who could help them navigate course-taking and share their strategies for success. One Black man said,

> "What helps is I'm declaring to be a mechanical engineer; I just recently declared that. [My peer mentor] is also a mechanical engineer, so he's taking the classes I'm going to take. I've been able to ask him advice about teachers to take, or when to take it, or what semester to take it in, so he's been like another advisor for me."

Similarly, other U-ENGIN students described how their peer mentors were an additional source of academic support during the first year. A Latina student shared, "He's kind of a friend who is like – he wants to make sure I'm doing as well as I can."

Regarding the academic benefit of informal relationships fostered through U-ENGIN, having a strong peer network prior to the academic year was advantageous as students encountered the difficulty of the engineering curriculum. U-ENGIN students relied heavily on their peers in engineering pre-requisite courses and leveraged their academic strengths to support each other. For U-ENGIN participants, study groups and tutoring opportunities were easily accessible. Having U-ENGIN peers readily available to provide assistance, or familiarity in a new academic environment, helped ease participants transition to college. Connections made through the U-ENGIN program proved to be essential in establishing a community of academic support and mitigating anxiety regarding transitioning to college-level courses.

These qualitative findings build upon the quantitative analyses by contextualizing the U-ENGIN students' perceived benefits of the formal aspects of the program (e.g., the summer transition program, academic coaching, and supplemental instruction) and providing insight into the importance of informal elements of program involvement, such as peer-to-peer interactions. Through the cultivation of academic and social support networks among participants, along with exposure and preparation for the rigor of an engineering curriculum, the U-ENGIN program appears to be instrumental in positively contributing to students' engineering self-efficacy during their first year of college.

8. Discussion

In this study we investigated how the engineering self-efficacy of Students of Color and White Students' participating in U-ENGIN, a cohort-based STEM intervention program (SIP), and their comparison group peers compared and changed over time. Additionally, we examined relationships between students' participation and perceived benefits of participating in U-ENGIN and their end-of-first-year engineering self-efficacy. Finally, we explored qualitative data to better understand how Students of Color participating in U-ENGIN influenced students' self-efficacy.

Although we expected participation in the U-ENGIN program to be positively associated with end-of-first-year engineering self-efficacy, regression analyses with U-ENGIN students and College of Engineering comparison group members revealed that U-ENGIN participation was not associated with end-of-first-year engineering self-efficacy. Findings also indicated that U-ENGIN Students of Color experienced an increase in engineering self-efficacy after the summer transition program. The engineering self-efficacy of Students of Color also decreased by the end of the first year but was not significantly lower than initial levels of engineering confidence before attending the pre-college summer program. This indicates that for Students of Color, the U-ENGIN program might have a buffering effect on students' engineering self-efficacy. Therefore, although participation in U-ENGIN may not have increased students' end-of-first-year engineering self-efficacy in relation to their comparison group peers, it is plausible that their participation in the program helped to sustain their self-efficacy throughout the academic year. The increase in engineering self-efficacy for Students of Color may result from the academic and social supports that helped students feel prepared for the academic year. Results from our qualitative analysis lend further support to this possibility, as Students of Color emphasized the role of the U-ENGIN summer program in preparing them for the demands of the engineering curriculum and connecting them with peers who provide social and academic support.

These findings align with Bandura's Theory of Self-Efficacy [26] as the courses provided during the summer transition program may have contributed to Students' of Color mastery experiences with content that students are likely to encounter in their first-year courses [29]. Additionally, connections formed with other U-ENGIN peers who were similarly navigating the College of Engineering may have also offered important vicarious experiences for Students of Color. The peer mentoring program allowed new U-ENGIN students to interact with advanced students who were academically and socially successful [28]. As a result, according to Bandura [26], students were able to gain confidence from witnessing peers, with similar characteristics as themselves, be successful in college. They were thus able to envision themselves as being successful like their peers, which also contributed to their self-efficacy. Having multiple sources of data was essential in discovering the importance of informal interactions in contributing to U-ENGIN students' engineering self-efficacy. Our quantitative measure of students' perceived benefits of participating in U-ENGIN neglected a crucial aspect of the program – peer-to-peer relationships. However, student interviews illuminated how peer relationships with fellow U-ENGIN participants fortified students' academic and social support networks during their first year of college.

For African Americans, participation in a summer bridge program sustained self-efficacy among participants from the time they entered the program to the beginning of their first year in college [17]. Johnson [17] discussed the importance of providing a "nurturing" environment for Students of Color, which included having student mentors that share similar backgrounds to provide guidance through college. He also indicated that decreases in self-efficacy can be attributed to barriers, such as not having a support network in college. Thus, programs like U-ENGIN can provide a community so that students are fully equipped to handle challenges encountered in their academic environment.

Our findings also indicate that students who found the U-ENGIN program to be beneficial were more likely to report higher levels of engineering self-efficacy at the end of the first academic year. The perceived program benefits variable utilized in this study captured students' perceptions of the helpfulness of formal aspects of the U-ENGIN program including family meetings, academic coaching, peer mentoring, academic and professional skill building sessions, along with supplemental instruction and study groups. Because this variable only measured the formal aspects of the program, there are other informal aspects of the program that we were able to identify within the qualitative analysis. In particular, we found exposure and preparation for engineering rigor and the cultivation of academic and social support networks to be elements that students discussed as contributing to engineering self-efficacy. Both Tovar [19] and Reid [20], who studied Latino students and Black men respectively, found that a lack of exposure to STEM coursework and a lack of community was associated with students' low levels of self-efficacy and confidence. Our study suggests that in developing a community of support and providing students with early exposure to engineering coursework, programs like U-ENGIN may positively contribute to participants' engineering self-efficacy.

A study regarding an engineering learning community of academically and financially at-risk students found that students believed financial support, specific course sections for people in the cohort, study groups, and peer mentoring and relationships contributed to their success and persistence in college [21]. The students in their study discussed the development of relationships with peers being particularly beneficial to success in their field of study along with academic and social support. We found similar results in our analysis of U-ENGIN Student of Color interviews at the end of their first year. U-ENGIN participants specifically highlighted the value of study groups and supplemental instruction sessions for science and math courses required by the program, along with peer-to-peer connections, which expanded students' social and academic support networks as they navigated their first year of college.

The qualitative findings of this study indicate additional linkages to Bandura's theory of self-efficacy. Beyond mastery and vicarious experiences, U-ENGIN participants provided insight as to how the program may support students through verbal and social persuasion, as well as attending to their emotional and physiological states during their first year in college. For instance, the encouragement provided by U-ENGIN coaches aligns well with verbal and social persuasion. Many U-ENGIN students highlighted the importance of relationships with U-ENGIN staff members who they approached with a variety of academic and personal concerns throughout the academic year. Students often discussed seeking out their coaches for advice and support during their first-year transition. In addition, students mentioned how participating in the U-ENGIN program helped alleviate some of the academic anxieties they had about the College of Engineering, by simulating the academic year in a lower-stakes environment during the summer transition program. By offering courses and study skill development in a supportive environment during the summer, the U-ENGIN program may have positively contributed to participants' emotional and physiological states in preparation for the academic year.

This work is also applicable in international contexts that share concerns about engineering self-efficacy and diversifying the engineering workforce [14–16]. An important distinction in the studies of these engineering SIPs is that they focus more on professional development or co-curricular programs than some U.S. SIPs which also seek to develop a community of students that feel connected to the university both academically and socially. Considering the variation in program elements can have benefits for researchers and practitioners across these contexts as they consider whether and how to integrate these different aspects of SIPs into their own programs, and study their ability to increase the diversity of the student population to improve the self-efficacy of their engineering students.

This study was limited in that it used self-reported perceptions of the benefits of the program. Future research should consider alternatives to the use of self-reported measures to assess participants' perceptions of a program's benefits. Further research should also consider how particular national or geographic contexts shape the racialized experiences of Students of Color and how SIPs may provide a supportive structure to combat such experiences. Although this was not thoroughly investigated in the study, discussions of race and racialized experiences frequently came up in our interviews with students. In addition to committing staff and other resources to mitigating such inequitable experiences, engineering programs should establish systems that support populations of students who continue to experience exclusion and marginalization in the field.

9. Conclusion

Although our findings indicated that there was no significant relationship between U-ENGIN participation and end-of-first-year engineering self-efficacy, we found that Students of Color had a significant increase in engineering self-efficacy after the summer transition program. Further, after the first year, engineering Self-efficacy of Students of Color returned to initial levels of self-efficacy when first entering the pre-college program. Our qualitative findings supported our quantitative conclusions indicating that an introduction to the curriculum and peer connections that fostered social and academic support integrated Students of Color into engineering thus contributing to their self-efficacy.

Comprehensive STEM-intervention programs, such as the U-ENGIN program, can have a critical role in supporting diverse students' successful transition into STEM majors and, ultimately, careers. By equipping students with the resources and skills needed to thrive academically during their first two years of college, SIPs can help students lay a foundation for academic excellence from which they can build upon in subsequent years of study. Since findings from this study focus specifically on students' engineering self-efficacy during their first year of undergraduate study, future explorations of the program's influence on engineering self-efficacy after the first year are warranted. However, this study has important implications for practitioners administering SIPs.

STEM intervention administrators should note that Students of Color might especially benefit from a replication of the school year during summer transition programs. Based on our research, we found that simulating engineering coursework during the summer prior to university enrollment, providing peer mentorship, creating a community that fosters peer-to-peer interactions, and utilizing academic coaches contributes to an academic and social support network that helps students recognize they can succeed. Universities should consider integrating these program elements in their SIPs to improve the opportunities for underrepresented students to succeed. Because our research was focused on Students of Color, it may be beneficial for future studies to analyze the impact of SIPs on the self-efficacy of other populations that are underrepresented in engineering, such as those with disabilities and women.

Overall, SIPs appear to have important effects on the success of students particularly in majors such as engineering. Studying the impact of SIPs on other STEM majors that have different academic cultures may produce different outcomes and thus further studies are warranted. Utilizing the social and academic structures that SIPs can provide for underrepresented populations may be key to not only diversifying STEM fields but retaining diverse student populations as well.

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