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WIP: Assessing The Impact of a Summer Bridge Program on Engineering Self-Efficacy

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WIP: Assessing The Impact of a Summer Bridge Program on Engineering Self-Efficacy

This work-in-progress paper investigates the impact of the summer bridge program, STEPUP, on participants' perceived engineering self-efficacy, as a measure of their transition to a large public university. The importance of this work lies in the established evidence that engineering summer bridge programs enhance student success, including retention and graduation rates. Engineering programs in the U.S. face persistent challenges with student retention and degree completion, which undermines the nation's long-term technological strength. Current data show that only about 30% of students graduate with an engineering degree within four years, and historically, roughly half complete their program within six years [1], [2]. Nearly one in every two students who start an engineering major ultimately withdraws before earning the degree.

A major contributor to these low retention and completion rates is the difficulty many students experience transitioning from high school to college-level engineering study [3], [4], [5], [6]. Globally, first-year students exhibit the highest rates of attrition due to the adjustment to a new academic and social environment, increased coursework rigor, evolving personal relationships, and the need for stronger time management and self-regulation skills [7]. In response, many engineering institutions have developed support structures, such as first-year seminars, introductory engineering courses, and summer bridge programs, to help ease this transition and bolster student success.

Summer bridge programs enhance academic performance, improve retention, and support students' adjustment to engineering study [8], [9], [10]. For instance, Beason et al. studied 109 undergraduate STEM students in the 6-week Meyerhoff Scholars summer bridge program, correlating a survey with positive correlations between sense of community, science identity, and research self-efficacy [11]. Sharpe et al. found TLSAMP's summer bridge program to be a best practice for student retention and success in STEM coursework [12]. However, outcomes vary based on program design and execution, emphasizing the importance of formal evaluation to determine impact and identify factors influencing student achievement.

The STEPUP Summer Bridge Program

The STEPUP program was established in 1995 with the goal of expanding participation in engineering among students from historically underrepresented groups. It is a six-week residential transition and success initiative designed to strengthen the recruitment, engagement, and persistence of incoming engineering majors. The overarching aim of STEPUP is to support students' academic readiness while also fostering personal growth and confidence as they enter the engineering profession. To achieve these outcomes, the program integrates multiple forms of support, including faculty and peer mentoring, community-building experiences, exposure to industry professionals, and coursework that reinforces key concepts in foundational STEM subjects. STEPUP operates through two coordinated components: an intensive summer residential session followed by continued support during the fall and spring semesters. Throughout the first year, participants receive individualized academic advising, structured mentoring, professional networking opportunities, and other student-support resources.

Participation in the summer residential portion is offered at a reduced cost, which covers housing, meals, instructional activities, transportation for corporate visits, program ceremonies, professional development sessions, and staffing.

A typical summer curriculum and activity schedule includes:

- Supplemental workshops in calculus, chemistry, and physics
- An engineering design course
- An introductory engineering seminar
- Coursework in either machine learning or engineering software tools
- Professional development sessions
- Corporate tours accompanied by guest speakers
- Team-building and cohort-strengthening activities
- Structured study halls and one-on-one tutoring

Further details regarding the program's structure and administration can be found in previous publications [13], [14]. Over the program's history, success metrics for participants have consistently outperformed those of non-participants [13], [14].

Engineering Self-Efficacy

This study evaluates the influence of STEPUP on students' engineering self-efficacy, offering insights into its effectiveness and identifying areas for strengthening students' confidence and persistence. Self-efficacy is crucial for engineering student success. Bandura's social cognitive theory defines self-efficacy as the belief in one's capability to perform tasks required to achieve goals [15]. These beliefs shape students' goals, effort, and resilience. Students with strong self-efficacy pursue ambitious goals, show greater persistence, and exhibit strong self-regulation, including problem-solving, critical thinking, and time management skills [16]. Self-efficacy develops through mastery experiences, vicarious learning, social persuasion, and emotional or physiological states [15], [16], [17], [18]. The STEPUP model incorporates practices aligned with each source, with a greater emphasis on mastery experiences and vicarious learning.

Mastery experiences or performance accomplishment involve structured opportunities to build competence, such as the EGN 2020C Engineering Design and Society course. Through hands-on design work and applied problem-solving, STEPUP students practice engineering skills and connect foundational math and science concepts to real-world applications.

Vicarious learning involves observing successful peers or mentors performing engineering tasks. STEPUP provides such experiences through faculty and peer mentoring, diverse role models, and industry speaker sessions.

Social persuasion involves encouragement and constructive feedback from others. STEPUP fosters supportive networks through cohort building activities, mentoring relationships, and involvement in student organizations and design teams, all within an inclusive learning environment.

Emotional and physiological states, such as stress and anxiety, can undermine self-efficacy. STEPUP addresses these factors through academic excellence workshops focused on metacognition, study strategies, and approaches for managing test or math anxiety.

As discussed, the theory of self-efficacy posits that mastery experiences and vicarious learning are sources that facilitate development of self-efficacy beliefs. Thus, it is predicted that there is a positive relationship between participation in the STEPUP program and students' perceived self-efficacy, such that STEPUP participants are likely to see increases in their perceived self-efficacy. To measure STEPUP's impact on engineering self-efficacy, this study utilizes a survey administered to program participants. Preliminary findings are shared and discussed in terms of shifts in student perceptions across multiple dimensions of engineering self-efficacy.

Methodology

This study employs a quantitative, pre–post research design adapted from prior work with this population [19]. Data were collected from first-year engineering undergraduates (age 18 or older) participating in the STEPUP summer bridge program. All participants completed surveys at the beginning and end of the six-week program.

Survey Instrument

Engineering self-efficacy was measured using the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) instrument [20]. Developed through National Science Foundation–supported research at Pennsylvania State University and the University of Missouri [21], LAESE is a validated 60-item measure designed to assess self-efficacy among undergraduate engineering students. The instrument captures several dimensions relevant to students' confidence and persistence, including their expectations for success, perceptions of workload, decision-making processes surrounding major choice, coping strategies, career exploration, and the influence of role models.

To evaluate changes in students' perceptions, the present study used a set of LAESE subscales with established reliability [21]. Consistent with our prior studies, the two engineering self-efficacy subscales I-II were combined into a single composite score for analysis. Items were rated on a 7-point Likert scale ranging from 0 (strongly disagree) to 6 (strongly agree).

Procedures

The study received Institutional Review Board approval (IRB #202201378). Participants provided informed consent electronically before beginning the survey. Recruitment occurred through program announcements and email invitations, which directed students to an online Qualtrics survey. Responses were linked using a unique participant identifier to allow for matched-pair analysis.

Surveys were administered during the first and final weeks of the residential summer program (July–August). Subscale scores from the pre- and post-assessments were exported from Qualtrics into Microsoft Excel for cleaning and further statistical analysis.

Data Analysis
Mean scores for each subscale were calculated for both timepoints. Paired-sample two-tailed *t*-tests were conducted using Excel and custom Python scripts to determine whether changes between pre- and post-survey scores were statistically significant. A significance threshold of $p < 0.1$ (due to the small sample size) was applied. Analyses were conducted at both the aggregate (group) level and the individual participant level.

Results

Demographics
The demographics of participants, including race/ethnicity and sex, are provided in Table 1.

Table 1. Data of STEPUP program participant demographics.

(N=28)	
Asian	39.29%
Black/African Amerian	7.14%
Hispanic/Latino	10.71%
Indigenous (Native American/Alaskan)	0%
Other	0%
Pacific Islander	0%
White	42.86%
Unknown	0%
Female	50%
Male	50%

Subscale Variations in Perceived Self-Efficacy at the Group Level
Appendix A provides the survey items for all subscales of engineering self-efficacy. Twenty-seven of the twenty-eight participants completed both the pre- and post-assessments, resulting in a 96% response rate. Figure 1 and Table 2 present the mean scores of all participants from the LAESE survey. As a group, the data indicates minimal to moderate changes in self-efficacy, with no statistically significant changes. Subscale 1 (engineering self-efficacy) and subscale 2 (coping self-efficacy) exhibited increases in mean scores from pre- to post-survey, with mean differences of 0.01 and 0.07, respectively. Conversely, there were decreases in mean scores from pre- to post-survey for subscales 3 (engineering career success expectations), 4 (feeling of inclusion), and 5 (math outcome expectations). Subscale 5 experienced the largest decrease, with a mean difference of -0.17.

Variation in Perceived Self-Efficacy Across Survey Items
To identify any significant effects, the mean difference for all participants per survey item was analyzed. Figure 2 illustrates the item-level paired differences along the response range, indicated by the confidence interval. Figure 3, on the other hand, demonstrates the statistical significance in relation to the paired effect size calculated by Cohen's *d* for each LAESE survey item.

Four survey items exhibited statistically significant changes. Q42, which states, "I can adjust to a new campus environment", and Q24, which asserts, "I can complete the math requirements for most engineering majors", demonstrated the largest positive mean differences of approximately 0.28 and 0.26, respectively. Both were statistically significant increases, as evidenced in Figure 4. Q39, which posits, "I can cope with being the only person of my race/ethnicity in my class," exhibited the largest negative mean difference of approximately -0.62, indicating a statistically significant decrease. Q33, which states, "Doing well at math will increase my sense of self-worth", demonstrated the second highest negative mean difference of approximately -0.59, also indicating a statistically significant decrease. Although not statistically significant, there were sizable effects for Q32 (positive effect) "I can make friends with people from different backgrounds and/or values" and Q14 (negative effect) "I can relate to the people around me in my class".

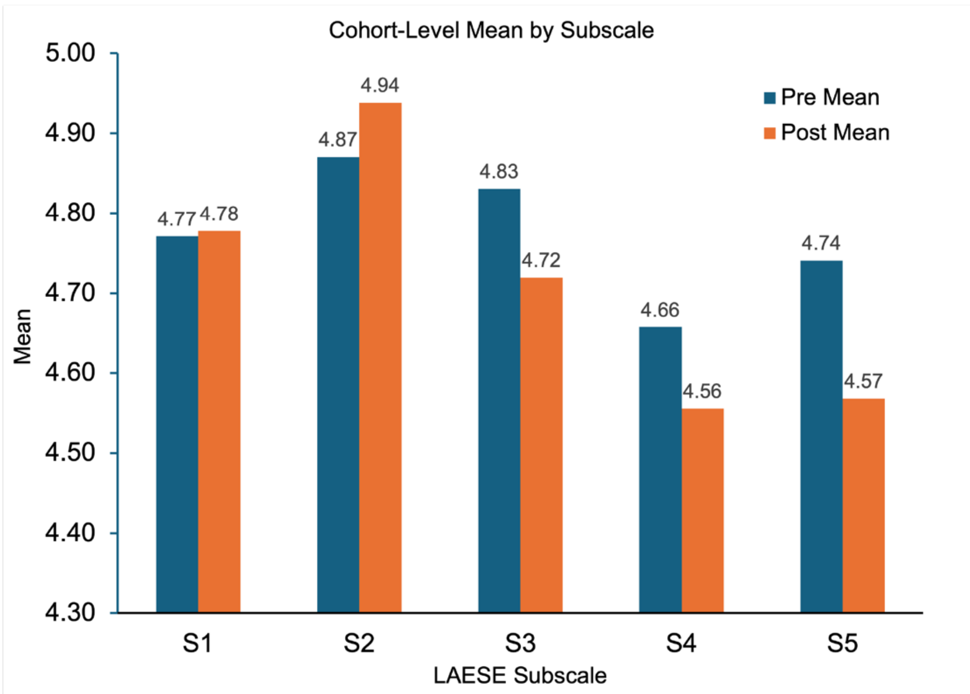

Figure 1. The graph presented illustrates the mean scores of participants (N = 27) for the pre- and post-response data from the LAESE engineering self-efficacy survey. Notably, none of the subscale changes in responses from pre- to post-survey were statistically significant ($p < 0.1$).

Table 2. A comprehensive table detailing pre- and post-response data for each subscale of the LAESE engineering self-efficacy survey. The table includes the mean, standard deviation (SD), *t*-statistic from the *t*-test, and *p*-value.

Subscale	Pre Mean	Pre SD	Post Mean	Post SD	T-Statistic	P-Value
S1	4.77	0.78	4.78	0.66	-0.06	0.95
S2	4.87	0.74	4.94	0.78	-0.78	0.44
S3	4.83	0.69	4.72	0.80	0.90	0.37
S4	4.66	0.88	4.56	1.01	0.69	0.49
S5	4.74	0.79	4.57	1.16	1.03	0.31

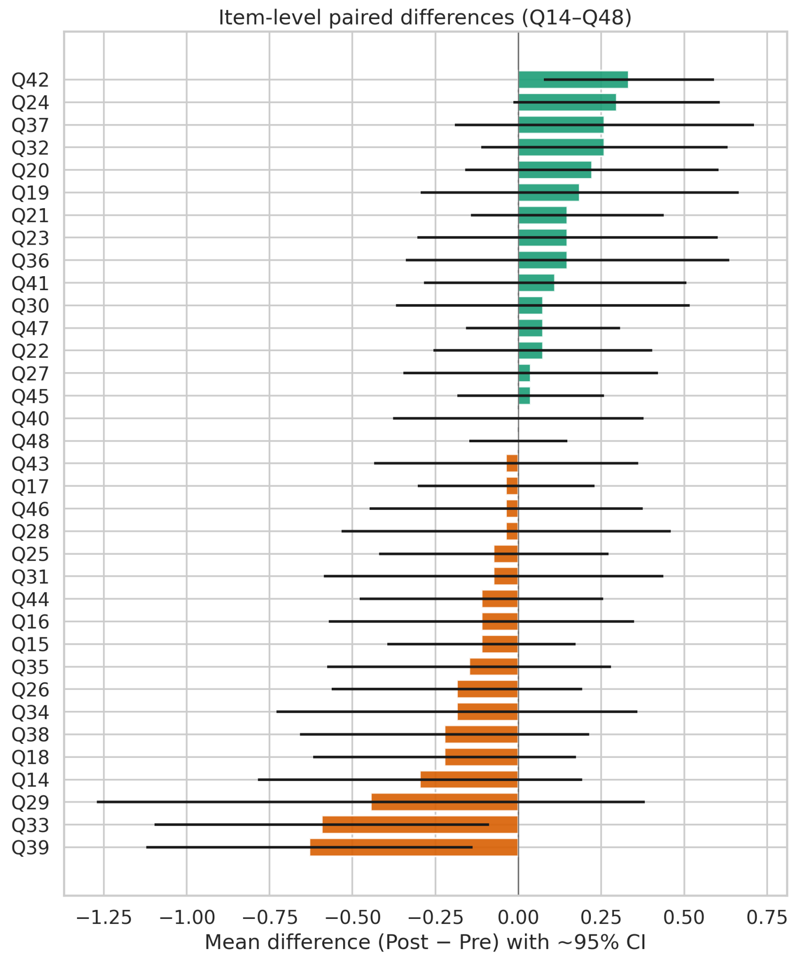

Figure 2. The forest plot illustrates the variation in the mean response across all LAESE survey items. Green signifies a positive mean difference which is an increase in mean value from pre- to post-survey response, while orange indicates a decrease. The horizontal line corresponding to each item represents the estimated 95% confidence interval.

Subscale Variations in Perceived Self-Efficacy at the Individual Level

Figure 4 illustrates the changes in mean scores across different subscales, considering variations in perceived self-efficacy among participants. Notably, 55% (15 out of 27) of participants exhibited an increase in mean response from the pre-survey to the post-survey for subscales 1 and 2. These results align with the group-level increases in means. Conversely, for subscale 3, 48% (13 out of 27) experienced an increase, while 40% (11 out of 27) saw a decrease. This discrepancy between individual responses on this subscale and the group-level mean decrease suggests that a larger number of participants experienced positive increases in self-efficacy on this scale. For subscale 4, 37% (10 out of 27) experienced an increase, while 40% (11 out of 27) saw a decrease, and 22% reported no change. For subscale 5, 44% (12 out of 27) experienced a decrease, while 29% (8 out of 27) saw an increase, and 26% reported no change.

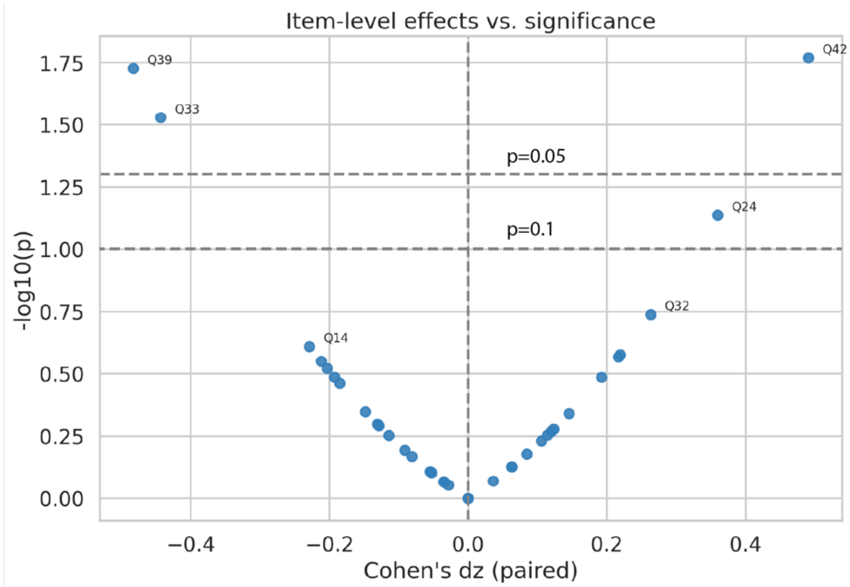

Figure 3. The volcano plot illustrates the statistical significance in relation to the paired effect size calculated by Cohen's *d* for each LAESE survey item. The dashed horizontal lines represent *p*-values of 0.05 and 0.1, with items above the line indicating statistically significant changes from pre- to post-survey responses. Items to the right of the dashed vertical line signify an increase (positive effect) in the response mean from pre- to post-survey, while items to the left (negative effect) denote a decrease.

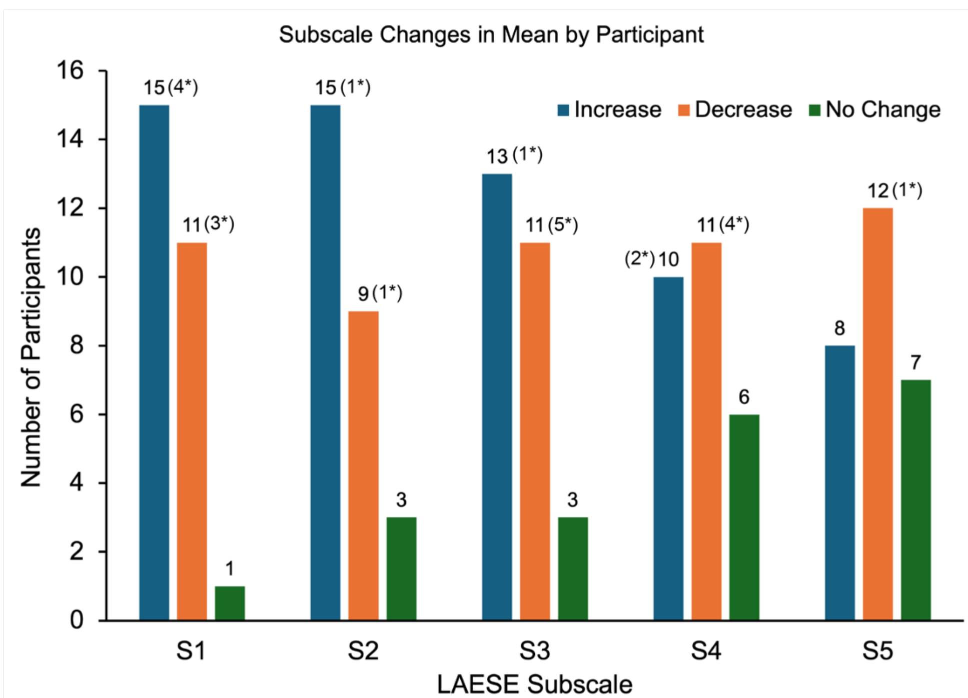

Figure 4. The graph presented illustrates the variation in mean scores for subscales of the LAESE engineering self-efficacy survey, indicating whether participants experienced an increase, decrease, or no change in their mean scores from pre- to post-response data. Statistically significant changes ($p < 0.1$) are indicated in parentheses.

Discussion

Aligned with Bandura's (1997) self-efficacy theory, the findings indicate that STEPUP positively supports students' emerging engineering self-efficacy through multiple sources of efficacy information. The hypothesis that participants would report increased perceived self-efficacy was supported by gains in Subscale 1, with a rise in the group mean and 55% of students showing positive change. These improvements can be attributed to STEPUP activities that provide vicarious experiences and broaden engineering exposure. Interactions with engineering student organizations, hands-on demonstrations and tours of faculty laboratories, and recognition at the closing ceremony allowed students to observe role models, visualize themselves in engineering roles, and receive social encouragement—all important contributors to vicarious learning and social persuasion within Bandura's framework.

Subscale 2 (coping self-efficacy) also increased at both group and individual levels, and Subscale 3 demonstrated predominantly positive individual gains. A particularly strong indicator of enhanced coping efficacy was the significant improvement on Q42 ("I can adjust to a new campus environment"). STEPUP's residential, cohort-based model requires students to practice independent living and navigate academic expectations, creating meaningful mastery experiences. Peer mentors further contributed to vicarious learning and social persuasion by modeling effective adaptation strategies and offering continuous support. Collaborative cohort activities, including group projects and shared academic challenges, also fostered an emerging sense of engineering identity as students began to view themselves—and be viewed by others—as future engineers. The program's focus on academic readiness, particularly through structured calculus workshops, appears to strengthen students' confidence in a domain foundational to engineering. The significant increase in Q24 ("I can complete the math requirements for most engineering majors") suggests that targeted academic support contributes to mastery experiences in mathematics, reinforcing broader engineering self-efficacy.

Despite these positive trends, declines in Subscales 4 and 5 (feelings of inclusion and math outcomes) warrant further examination. Significant shifts in items such as Q39 and Q14 point to complex interactions between students' sense of belonging, their ability to relate to classmates, and perceptions linked to being the only person of their race or ethnicity in a classroom. Similarly, changes in Q24 and Q33 highlight potential tensions between mathematical performance and self-worth. While STEPUP effectively enhances several dimensions of engineering self-efficacy, students' socio-emotional experiences, especially around inclusion and identity, may require further qualitative exploration to fully understand and address.

Conclusion

Preliminary analyses show measurable gains in engineering self-efficacy among students who completed the STEPUP summer bridge program. These findings will be included in a broader longitudinal dataset. While limited sample size limits generalizability, they align with other program impact indicators like retention, graduation, and participant/faculty feedback, supporting the program's effectiveness. Insights from this study may guide future refinements to STEPUP and similar initiatives, as bridge programs are crucial for easing students' transition into engineering curricula.

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Appendix A

	S1 - Engineering Self-Efficacy I and II - Survey Items
1	I can succeed in an engineering curriculum (Q15)
2	I can succeed in an engineering curriculum while not having to give up participation in my outside interests (e.g. extra curricular activities, family, sports) (Q19)
3	I will succeed (earn an A or B) in my physics courses (Q21)
4	I will succeed (earn an A or B) in my math courses (Q22)
5	I will succeed (earn an A or B) in my engineering courses (Q23)
6	I can complete the math requirements for most engineering majors (Q24)
7	I can do well in an engineering major during the current academic year (Q27)
8	I can complete any engineering degree at this institution (Q29)
9	I can complete the physics requirements for most engineering majors (Q35)
10	I can persist in an engineering major during the next year (Q40)
11	I can complete the chemistry requirements for most engineering majors (Q44)

	S2 - Coping Self-Efficacy - Survey Items
1	I can cope with not doing well on a test (Q30)
2	I can make friends with people from different backgrounds and/or values (Q32)
3	I can cope with friends' disapproval of chosen major (Q37)
4	I can cope with being the only person of my race/ethnicity in my class (Q39)
5	I can approach a faculty or staff member to get assistance (Q41)
6	I can adjust to a new campus environment (Q42)

	S3 - Engineering Career Success Expectations - Survey Items
1	Someone like me can succeed in an engineering career (Q17)
2	A degree in engineering will allow me to obtain a well paying job (Q26)
3	I expect to be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter engineering (Q28)
4	A degree in engineering will give me the kind of lifestyle I want (Q31)
5	I expect to feel "part of the group" on my job if I enter engineering (Q34)
6	A degree in engineering will allow me to get a job where I can use my talents and creativity (Q38)
7	A degree in engineering will allow me to obtain a job that I like (Q43)

	S4 - Feeling of Inclusion - Survey Items
1	I can relate to the people around me in my class (Q14)
2	I have a lot in common with the other students in my classes (Q16)
3	The other students in my classes share my personal interests (Q18)
4	I can relate to the people around me in my extra-curricular activities (Q20)

	S5 - Math Outcome Expectations - Survey Items
1	Doing well at math will enhance my career/job opportunities (Q25)
2	Doing well at math will increase my sense of self worth (Q33)
3	Taking math courses will help me to keep my career options open (Q36)

Figure 5. The LAESE engineering self-efficacy survey items categorized by subscales denoted by (S). The actual survey item number is denoted in parenthesis by (Q#).