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WIP: Empowering Future Engineers: The Impact of a Summer Bridge Program on Student Self-Efficacy

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Introduction

Low retention and graduation rates in engineering are well-known challenges to maintaining America's technological competitiveness. Recent studies indicate that the U.S. four-year engineering graduation rate is about 30% [1]. Over the past 65 years, the six-year engineering graduation rate has been about 50% [2]. This means that roughly half of all students who begin studying in an engineering bachelor's degree program will drop out of the program before graduating. However, the urgency of this problem is further emphasized by a looming workforce crisis: the U.S. will need approximately 400,000 new engineers annually [3].

Low retention and graduations rates can be attributed to the fact that the transition from high school to college can be difficult for students in terms of academic, professional, and personal development [4], [5], [6], [7]. This is evident by the worldwide dropout rate of college students being highest in the first year of college as students must transition to a new campus environment, rigors of academic work, changes in personal relationships, social inclusion, and time-management among many other factors [8]. To address these issues, many engineering colleges have implemented programs such as first-year experiences, introduction to engineering courses, and bridge programs to facilitate the transition to college and improve student outcomes. Research suggests that engineering summer bridge programs can be highly effective in improving academic performance, retention rates, and overall success of students [9], [10], [11]. However, the effectiveness of these programs can vary depending on the program structure and implementation. Therefore, it is crucial to assess the effectiveness of bridge programs and gain a comprehensive understanding of the factors that influence student outcomes.

This study investigates the changes in engineering self-efficacy among students enrolled in the Successful Transition and Enhanced Preparation for Undergraduates Program (STEPUP) at the University of Florida (UF). In 1995, the program was created to support underrepresented students pursuing the engineering degree. STEPUP is a six-week residential college transition and student success program designed to facilitate the recruitment, motivation, and retention of first-year engineering students. The program's primary objective is to enhance the academic and personal development of these students. STEPUP employs a comprehensive approach to achieve its goals, including mentorship involving both faculty and peers, community-building activities, industry engagement, and academic enhancement courses in foundational engineering disciplines. The program comprises two distinct components: a six-week summer residential program and a non-residential fall and spring semester program. Throughout the entire freshman year, program support services are provided to students in the form of personalized academic advising, faculty and peer mentoring, corporate networking, academic and other student support services, see Figure 1.

Students selected to participate in the STEPUP program must first receive an official letter of admission from the UF Office of Admissions. From this pool of admitted applicants, the Herbert Wertheim College of Engineering (HWCOE) is provided with a list of students who have selected an engineering field as their major of choice. Correspondence is targeted towards these students both electronically and in writing to congratulate them on their success in being admitted to the University and to welcome them into the College. Students electing to apply to the program must submit a resume, cover letter, high school transcript, and two letters of recommendation. Applications are then scored and assessed based on the perception of their ability to successfully manage the rigor of the program schedule and their ability to contribute towards the experiential learning goals of the program overall.

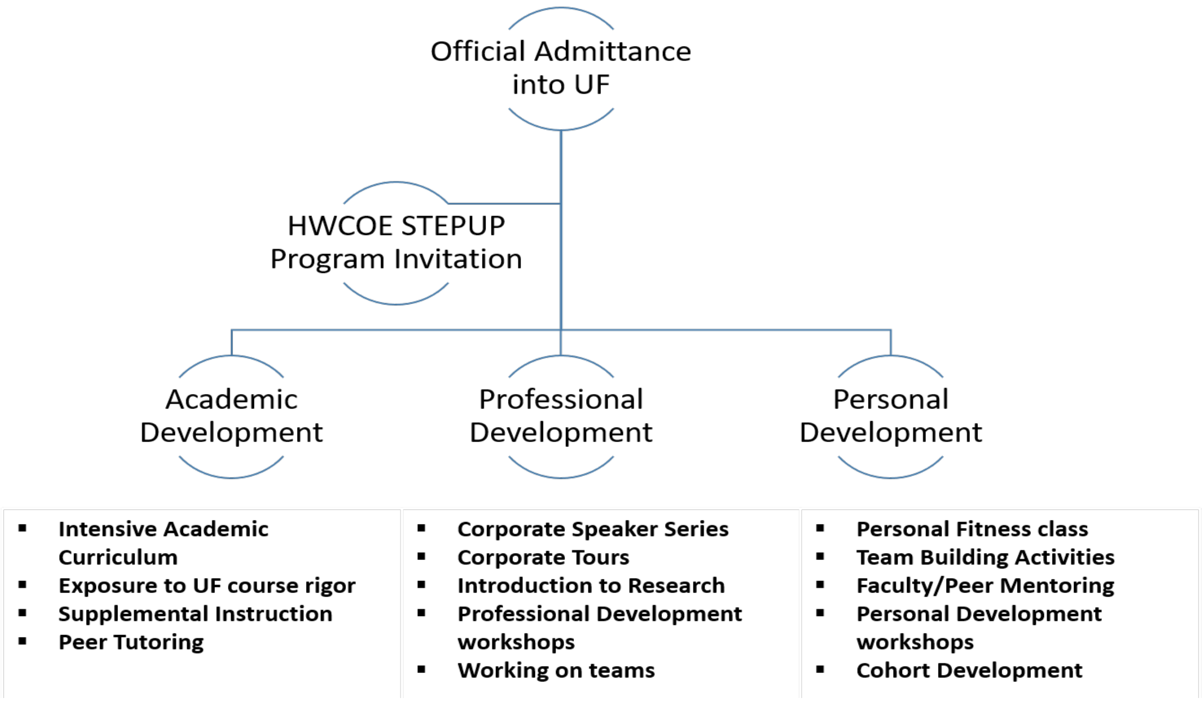

Figure 1. Diagram of the STEPUP program structure [12].

The estimated cost of participation for the academic year is approximately $6,000 per student, which encompasses summer housing, meal plans, classes, corporate tours, opening and closing ceremonies, professional development programming, and program staff. Program costs are funded through a combination of internal (HWCOE) funding, corporate sponsorships, and alumni donations. Program participants are required to pay an application fee of $800.00. Financial hardship is considered, and the fee may be waived.

A typical summer program schedule includes the following classes and/or activities:

- Calculus, Chemistry, and Physics supplemental workshops
- An Engineering Design course
- An Introduction to Engineering class
- Introduction to Machine Learning or Engineering Software course
- Professional Development workshops
- A corporate tour and speaker series
- Team-building activities
- Study halls and individual tutoring

Further details regarding the program's structure and administration can be found in previous publications [12], [13]. Over the program's history, success metrics for participants have consistently outperformed those of non-participants, particularly for students from underrepresented populations [12], [13]. The present study aims to assess the impact of STEPUP on engineering self-efficacy, providing valuable insights into the program's effectiveness and identifying student needs in fostering self-efficacy.

The level of a student's self-efficacy significantly influences their successful completion of an engineering degree. Self-efficacy, as defined by Albert Bandura's theoretical framework of psychological behavioral change, refers to an individual's belief in their ability to perform a specific task [14]. It is task-specific rather than generalized. In the literature, it is defined as: "a judgment about one's ability to organize and execute the courses of action necessary to attain a specific goal" [15]. Self-efficacy influences the selection of goals students pursue, the effort they invest in achieving these goals, and their persistence in overcoming difficulties. For instance, students with high self-efficacy set more challenging goals and are more diligent in accomplishing them compared to students with low self-efficacy. High self-efficacy is associated with enhanced self-regulation, including more efficient utilization of problem-solving and critical thinking skills, and effective time management [15], [16].

Self-efficacy beliefs are developed through four primary sources of information: mastery experience, vicarious learning, social persuasion, and physical reactions [14], [15], [16]. The STEPUP program model incorporates evidence-based elements that should facilitate the development and enhancement of self-efficacy as students progress through the program.

Mastery Experience or Performance Accomplishment: provides students the opportunity to learn and practice the rules and strategies needed to effectively perform a task. Students in STEPUP take EGN 2020C Engineering Design and Society. The course provides opportunities for practice of engineering skills through hands-on design experience, critical thinking tasks, and pulls together for students how math and science are applied to provide innovative solutions to complex problems.

Vicarious Learning: refers to learning through observing someone else perform a task. An example of vicarious experience would be a novice student observing a more advanced student assemble a robot, and the novice student thinks: "If she can design and construct a robot, so can I." Role models and experts can have a high influence on self-efficacy when they are perceived as similar to the observer [15]. STEPUP provides vicarious experiences through peer and faculty mentoring, diverse faculty engagement, and a corporate/professional development speaker series.

Social Persuasion: originates from judgments, feedback, and support from other people. Positive feedback and encouragement that is perceived by the receiver as genuine enhances self-efficacy. Negative feedback diminishes self-efficacy. STEPUP is designed to establish strong social support through cohort building activities including coaching, mentoring, and participation in affinity groups such as engineering student organizations and design teams. Also, the commitment to an inclusive learning environment and diverse faculty contributes to positive support.

Physical Reaction/Emotional Arousal: Physical or emotional reactions can have a positive or negative effect on the perception of self-efficacy. For example, increased heart rate, body temperature, or sweating associated with stress or anxiety about a task can cause self-doubt and poor performance. STEPUP provides for academic excellence workshops that promote metacognition and test preparation skills including overcoming math/test anxiety.

To examine the impact of STEPUP on engineering self-efficacy, a survey instrument is used. Preliminary results of the survey are presented, and outcomes are discussed in relation to changes in participant perceptions across various classifications of engineering self-efficacy.

Assessment Methods

Quantitative data is obtained through pre- and post-program assessment surveys. The participants are male and female undergraduate students aged 18 and older who are enrolled in their first year of college and pursuing a degree in engineering.

The Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey was utilized to assess changes in engineering self-efficacy [17]. The instrument was developed by the Pennsylvania State University and the University of Missouri with funding from National Science Foundation grants HRD0120642 and HRD0607081 [18]. LAESE evaluates the self-efficacy of undergraduate engineering students. It has been validated through testing and research involving both male and female students. The instrument comprises 60 items and requires approximately 15 minutes to complete. LAESE addresses the following domains related to self-efficacy: student efficacy in challenging situations; outcomes anticipated from pursuing engineering; student expectations regarding workload; student decision-making process regarding major selection; student coping strategies in difficult circumstances; career exploration; and the influence of role models on study and career choices.

Subscales of the data were used to assess student's perceptions and to gauge changes in self-efficacy. The following subscales along with the underlying concept related to self-efficacy are provided. After each concept is the Cronbach's alpha that indicates the reported reliability of the subscale (acceptable reliability is $0.70 < \alpha < 0.90$) [18]:

- Engineering career success expectations – 7 items, $\alpha = 0.84$
- Engineering self-efficacy I – 5 items, $\alpha = 0.82$
- Engineering self-efficacy II – 6 items, $\alpha = 0.82$
- Feeling of inclusion – 4 items, $\alpha = 0.73$
- Coping self-efficacy – 6 items, $\alpha = 0.78$
- Math outcome expectations – 3 items, $\alpha = 0.84$

Each item for a subscale utilizes a 7-point Likert-type scaled response, from 0 (strongly disagree) to 6 (strongly agree). Statistical analysis was performed on the survey responses across four of the six subscales (engineering self-efficacy I and II, coping self-efficacy, and engineering career success expectations). The other two subscales will be included in subsequent studies.

This study was approved by an institutional review board under IRB 202201378. Informed consent was obtained from the study participants via online agreement prior to completing the survey instrument. Participants were recruited via in-person program announcements and email. Participants were directed to a web link in the recruitment email to complete the online survey. The online survey was developed and analyzed in Qualtrics experience management software.

The summer bridge program was a residential program with a duration of 6 weeks (July – August). Pre- and post-surveys were administered during the first week of the summer program and the week following the program's conclusion, respectively. From the STEPUP program's 37 participants, a sample of 6 anonymous participants were studied, which represents 16% of the population. The same 6 participants' pre and post responses were tracked via an assigned participant number. Scores for each subscale of pre and post survey responses were downloaded from Qualtrics to Microsoft Excel. Using Excel, the mean scores for pre and post responses were calculated then compared using a two-tailed paired sample *t*-test. Scores were considered significantly different if $p < 0.05$.

Results and Discussion

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

Table 1. Data of STEPUP program participant demographics.

(N=37)	
American Indian/Alaskan Native	5%
Asian/Pacific Islander	13%
Black/African American	26%
Hispanic/Latino	31%
Unknown	5%
White	44%
Male	43%
Female	57%

The survey items for subscales of engineering self-efficacy I and II and participant mean scores are provided in Figure 2.

The results indicate overall positive changes in engineering self-efficacy from all participants. Two out of six of the participants had mean score changes that were statistically significant, which is 33% of the sample size. Students 3 and 4 had scores that significantly increased with mean scores increasing from 5.09 ± 0.7 to 5.73 ± 0.6 (p=0.009) and 5.09 ± 0.3 to 5.82 ± 0.6 (p=0.009), respectively. Also, it is noted that all participants had relatively high perceived engineering self-efficacy scores prior to the STEPUP program as indicated by a pre-survey mean score of 5.32/6. These results corroborate the historical findings of student participants in the STEPUP summer bridge program who have higher quantitative performance metrics than non-participants such as two-year retention and graduation rates [12]. Also, the positive results align with the elements (i.e., mastery experience, vicarious learning, social persuasion, and physical reactions) of the STEPUP program structure as discussed in the introduction section that have been shown in the literature to promote self-efficacy [14], [16], [19]. Larger sampling of participants will increase data confidence on these outcomes. Qualitative inquiries of participants could help to better understand what specific aspects of STEPUP have the greatest impact on engineering self-efficacy. Data pertaining to subscales of coping self-efficacy and engineering career success expectations are presented Figures 3 and 4.

a

	Engineering Self-Efficacy I and II - Survey Items
1	I can succeed in an engineering curriculum
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)
3	I will succeed (earn an A or B) in my physics
4	I will succeed (earn an A or B) in my math courses
5	I will succeed (earn an A or B) in my engineering courses
6	I can complete the math requirements for most engineering majors
7	I can do well in an engineering major during the current academic year
8	I can complete any engineering degree at this institution
9	I can complete the physics requirements for most engineering majors
10	I can persist in an engineering major during the next year
11	I can complete the chemistry requirements for most engineering majors

b

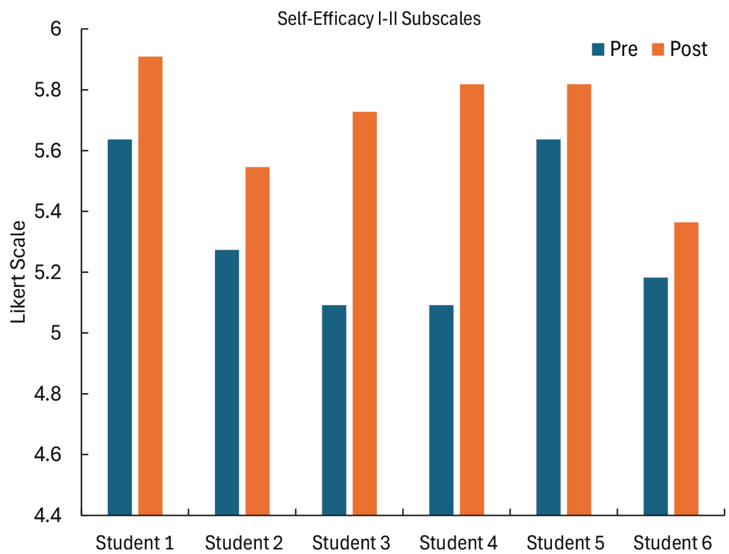

Figure 2. a) Survey items for the LAESE engineering self-efficacy survey, specifically for subscales of engineering self-efficacy I and II, are presented. b) Graph of mean scores of pre and post response data from the LAESE engineering self-efficacy survey for subscales of engineering self-efficacy I and II.

a

	Coping Self-Efficacy - Survey Items
1	I can cope with not doing well on a test
2	I can make friends with people from different backgrounds and/or values
3	I can cope with friends' disapproval of chosen
4	I will succeed (earn an A or B) in my I can cope with being the only person of my race/ethnicity in my class math courses
5	I can approach a faculty or staff member to get assistance
6	I can adjust to a new campus environment

b

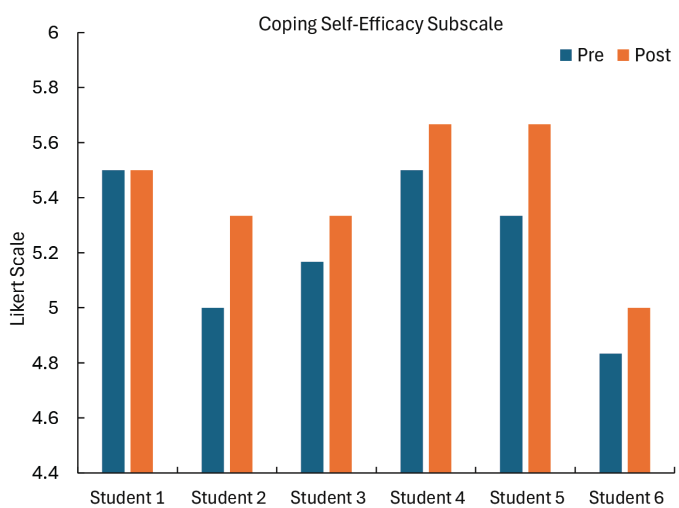

Figure 3. a) Survey items for the LAESE engineering self-efficacy survey, specifically for the coping self-efficacy, are presented. b) Graph of mean scores of pre and post response data from the LAESE engineering self-efficacy survey for the coping self-efficacy subscale.

The results indicate overall positive changes in participants' coping self-efficacy and engineering career success expectations self-efficacy. For the coping self-efficacy subscale, one student participant (student 1) had no change in self-efficacy and the other five students had increases in self-efficacy. However, none of the changes were considered statistically significant ($p < 0.05$).

For the engineering career success expectations subscale, all participants showed increases in mean scores. However, none of the changes were considered statistically significant ($p < 0.05$). Generally, students entered the program with relatively high levels of perceived self-efficacy as indicated by survey mean scores of participants being greater than (5). Scores less than (5) were observed for student 6 in coping self-efficacy and three student participants (students 2,4,6) in the career success expectations subscale.

a

	Engineering Career Success Expectations - Survey Items
1	Someone like me can succeed in an engineering career
2	A degree in engineering will allow me to obtain a well paying job
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
4	A degree in engineering will give me the kind of lifestyle I want
5	I expect to feel "part of the group" on my job if I enter engineering
6	A degree in engineering will allow me to get a job where I can use my talents and creativity
7	A degree in engineering will allow me to obtain a job that I like

b

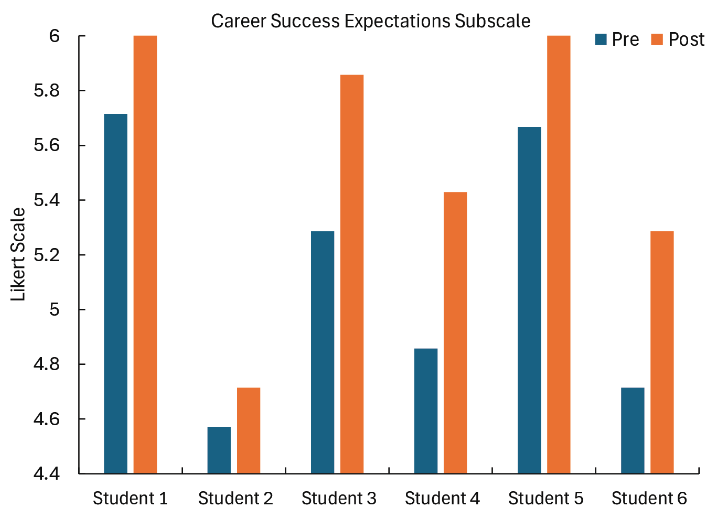

Figure 4. a) Survey items for the LAESE engineering self-efficacy survey, specifically for the engineering career success expectations subscale, are presented. b) Graph of mean scores of pre and post response data from the LAESE engineering self-efficacy survey for the engineering career success expectations subscale.

Collectively, student participants had the highest increase in subscale mean score (0.41) for engineering career success expectations. This finding may be attributed to the professional development activities STEPUP provides including weekly speakers from industry and/or site visits to corporate engineering firms. Subsequent studies will help to better validate this claim. As an initial implementation of the survey, the authors acknowledge the necessity for a larger sample size. This data will be integrated into a larger and ongoing dataset. Moving forward, the authors are confident that the post-survey response rate will augment the current results as the LAESE program becomes an annual component of the summer bridge program and incentives are implemented. The current results, while not generalizable, serve to corroborate other measures of program feedback and program success, such as retention and graduation rates, and qualitative feedback from participants and faculty.

Conclusion

Preliminary findings from this study indicate positive changes in engineering self-efficacy among students who participated in the STEPUP summer bridge program. These results can serve as a component for assessing the program's effectiveness in supporting student success. The post-program survey response rate fell short of expectations which limited the sample size.

This is likely attributable to the survey's administration after the summer program's conclusion, when students had returned home, and the absence of incentives for participation. Future efforts will address these issues, resulting in a more robust response and larger sample size for more in-depth statistical analysis. Bridge programs that facilitate successful academic transition to college are crucial for enhancing engineering retention and graduation rates. In the future, the outcomes of this study can be utilized to enhance the effectiveness of summer bridge programs, thereby producing engineers who meet the projected workforce demand.

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