Exploration of a Bridge Program to Increase Student Understanding of Emerging Technological Fields

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Abstract: Bridge programs are common interventions colleges implement to improve student recruitment, retention, and performance. Key components are typically specific content instruction, tutoring, mentoring, and college orientation. This paper provides the results of a short-duration summer bridge program designed to increase student awareness of emerging technological fields in engineering technology (ET), specifically the semiconductor and data center industries. High school students in the summer bridge program were provided with information about NOVA's ET programs, participated in hands-on activities around topics important to semiconductor and data center operations (DCO) technician careers, and met industry representatives through industry site tours. Student data includes participant changes in understanding of ET educational and career pathways, knowledge of OSHA and industrial safety, understanding of college success skills and strategies, and interest in ET careers. Results of the study demonstrated that students of all subgroups (e.g., gender, grade level, race, ethnicity) exhibited equivalent improvement in their understanding of ET education and career pathways while student outcomes in OSHA and college success skills varied by subgroup. Based on these results, the use of a short-duration bridge program is one mechanism for post-secondary institutions to increase awareness of emerging technologies and educational pathways to support careers in those technologies.

Keywords: bridge programs, student programs, engineering technology, semiconductor, data center operations, emerging technologies, industry site visits

Introduction

Overview

Many higher education institutions aim to increase recruitment and retention in STEM through voluntary, institution-sponsored, co-curricular opportunities, such as bridge programs. With a rapidly increasing workforce within multiple engineering technology fields, community colleges are uniquely situated to help fortify the workforce pipeline for engineering technology (ET) fields such as data center operations, semiconductor manufacturing, and biotechnology [1]. However, community colleges often struggle to raise awareness and sustain recruitment strategies. Bridge programs are often aimed at increasing the participation of groups historically underrepresented in STEM. They offer a unique opportunity to diversify and broaden the pool of applicants in an industry that struggles to recruit and maintain an ever-expanding workforce [2].

According to a recent report from the Semiconductor Industry Association, as a result of incentives of the CHIPS (Creating Helpful Incentives to Produce Semiconductors) and Science Act, national semiconductor manufacturing is expected to increase by 200% by 2032. This increase in manufacturing is expected to attract $646 billion in capital investments. To meet the rising demands, experts highlight the importance of broadening the STEM pipeline and investing in scientific research to match the investments in semiconductor production and R&D [3]. A 2022 report from Deloitte [4] indicates that more than one million skilled workers will be needed by 2030 to solve the global semiconductor workforce shortage.

The Data Center Operations field is currently experiencing a rapid increase in demand for positions. Researchers estimate North America will see a net growth of approximately 85,000 jobs in data centers over the next few years. Of these jobs, 85% are in operations and maintenance of the centers themselves [5]. While the number of jobs in data center operations continues to rise, the number of qualified staff available to fill these positions does not appear to be keeping pace. I-Masons estimate that there will be upwards of 100,000 vacant jobs in data center operations in the coming years [6]. In a survey of data center owners and operators, 1 in 5 respondents identified the difficulty of hiring and retaining qualified staff as the single largest challenge moving forward [7-8].

To address the growing demand for qualified DCO staff, community colleges have initiated outreach programs in collaboration with industry partners [9-10]. As associate degrees are outpacing the 4-year colleges in enrollment of engineering technology, it is logistically sound to situate engineering technology programs within [11]. Furthermore, engineering technology comprises one of the largest groups of STEM students enrolled in community colleges nationwide. Researchers have identified community colleges as a significantly underutilized pool of STEM talent [12]. However, there remains a considerable lack of awareness among students and faculty regarding the distinctions between engineering and engineering technology and the legitimacy of the engineering technology field. This study seeks to bridge this gap in the literature by exploring student perspectives on engineering technology to enhance outreach efforts.

Research Motivation

The NOVA Summer Bridge Program was designed to increase student awareness of emerging technological fields in engineering technology (ET) and recruit students from underrepresented backgrounds in STEM and ET. To examine the efficacy of the multiple mechanisms of the initiative across all of the participants, we sought to answer the following two research questions:

RQ1. What are student perceptions that the bridge program improved their understanding of the ET field, ET-related career competencies, and college success skills?

RQ2 - What are the differences across demographic groups regarding students' understanding of the ET field, ET-related career competencies, and college success skills?

Methods

Summer ET Bridge Program Design

The summer ET bridge program was designed to raise awareness of engineering technologies and omitted remedial coursework and college coursework like those found in more traditional bridge programs. The bridge program was hosted at four of NOVA's campuses over two years, and students were provided transportation between campuses during their program. The program took place over eight days in the summer and served rising seniors and recent graduates, emphasizing recruiting traditionally underrepresented students in ET fields. The program's primary activities consisted of a combination of hands-on learning and industry site visits. Hands-on learning activities included modules on pneumatic controls and industrial controls, with students controlling valves, sensors, and logic controllers to investigate closed systems. During year 1, students completed cabling and splicing labs using ethernet cables and received an introduction to motor and process control using NOVA's Amatrol workstations. During year 2, the program utilized LJ Create's tabletop pneumatics trainer, industrial control trainer, and virtual circuit builder with their integrated learning labs. This change allowed NOVA to offer the program at multiple sites while standardizing the curriculum. In both years, students completed a day of instruction onsite at an operational data center. Activities at the data center varied depending on the maintenance and operation schedules of the facility/ All labs and hands-on instruction were intended to introduce the types of skills a technician would need to be effective in the modern engineering technology workplace.

Through participation in the program, students also had the chance to earn two credits, a one-credit College Success Skills course (SDV 101) and a one-credit Industrial Safety course emphasizing the Occupational Safety and Health Act (SAF 130). Both courses are required for ET credentials at NOVA and serve to accelerate student's trajectory through the NOVA system if they continue on with the degree program. A more detailed guide of the bridge program's components is depicted in Table 1.

Table 1: Bridge Program Components

Component	Description
NOVA Campus Introduction and Resources	Tour NOVA campuses and meet with representatives from Student Services, Admissions, Financial Aid
College Success Skills Course SDV 101 – 1 credit	Required course for all NOVA students focused on topics such as Academic Planning and Career Exploration, Goal Setting, Communication, Financial Literacy, and Time Management
Industrial Safety OSHA 10 SAF 130 – 1 credit	Required course for all ET credentials that emphasizes safety standards, the Occupational Safety and Health Act (OSHA), and its rules and regulations (OSHA 10).
Introduction to Engineering Technology and Data Centers	Hands-on instruction and labs on topics such as electronic relays, programmable logic controllers, mechatronics, pneumatics, industrial control, and power distribution.
Data Center Tour	Tour of the STACK Infrastructure data center with discussion on critical topics and DCO career pathways
ET Tour	Tour of the Micron Technology's Manassas fabrication facility and discussion on ET career pathways

Program and Sample Demographics

Across the three offerings of the program, once in 2022 and twice in 2023, 34 students participated in the program. Students were either rising seniors or about to enter college, with a majority of students being rising high school seniors (N=22). While most participants identified as male (N=21), roughly 38% of the bridge programs participants identified as female. Similarly, while a plurality of students identified as Asian (N=11), 50% of the participants self-identified with races or ethnicities that are underrepresented within STEM. Table 2 shows the complete demographic breakdown of students who participated in the summer bridge program.

Table 2: Summer Bridge Program Participants

Participant Demographics	N	Percent
Gender		
Male	21	62%
Female	13	38%
Race/Ethnicity		
White	6	18%
Asian	11	32%
Black or African American	5	15%
Hispanic or Latino	8	24%
Multiracial	4	12%
Grade		
11th	22	65%
12th	12	35%
Total	34	100%

[a]*Percentages will not add to 100 since applicants could choose more than one race/ethnicity*

Results and Discussion

Data Collection

Data was collected from students at the end of the bridge program via an online survey. The survey consisted of 27 questions with both Likert-scale and short-answer responses. The researchers left the room while the survey was conducted to mitigate the influence of the researchers on the study's results. The survey consisted of multiple sections: program evaluation, student perceptions of industry skills focused on OSHA 10, college success skills, and understanding of the broader ET field. Likert-like responses were rated on a 5-point scale, from Strongly Disagree (1) to Strongly Agree (5).

Data Analysis

Researchers utilized independent sample t-tests to examine the differences in scores across three sets of questions, examining student preconceptions of engineering technologies, student knowledge of engineering technology-related industry skills, and various college success skills. Within the sample, independent sample t-tests were run to examine differences in understanding of engineering technology between male and female students, overrepresented majority or underrepresented minority students, and rising high school seniors (11^{th}) and incoming first-year college (12^{th}) grade students. Additionally, participants were asked to rate their pre- and post-understanding of various ET industry and college success skills. Independent sample t-tests were used to examine the differences in students' understanding across the whole sample and for specific demographic groups. P-values were determined using two-tailed hypotheses to ensure no prior assumptions of the directionality of the summer bridge program's effect were made. Additionally, equal variances were not assumed across the samples due to the low sample size. Paired sample t-tests were used to examine pre/post scores of students' understanding of industry-related skills and college success skills.

Prior Knowledge of Engineering Technologies

To examine the efficacy of the Introduction to Engineering Technology and Data Centers component of the summer bridge program, students were asked four questions about their understanding of various aspects of Engineering Technology. Namely, students were asked how the bridge program developed their understanding of the types of available ET careers, the types of available ET degrees and certifications, and the skills required for ET careers. Students were also asked how the program increased their interest in the program. Responses from across all four questions scored an average of approximately 4 (Agree), with standard deviations ranging from 0.729-0.8, which is depicted in full detail in Table 3. Additionally, independent sample t-tests were conducted to examine if certain subgroups of participants gained more from the summer bridge program when compared to their counterparts.

Table 3: Student Understanding of Engineering Technology Careers (n=34)

Participating in the summer bridge program increased my understanding of ...	Mean	SD
Types of ET Careers	4.11	0.8
Interest in ET Careers	4.14	0.729
Types of ET degrees and Certifications	4.18	0.81
Skills for ET Careers	4.04	0.85

Note: SD Standard Deviation. Scale: 1=Strongly Disagree; 2=Disagree; 3=Neither Agree nor Disagree; 4=Agree; 5=Strongly Agree.

The second research question is concerned with examining the efficacy of various aspects of the summer bridge program for all students, especially those who have been historically underserved in STEM and ET fields. To answer this research question, Table 4 highlights the differences in scores across student demographic groups through independent sample t-tests. There were no statistically significant differences in examining scores across demographic groups of the four areas pertaining to ET. The high p values indicate that the hands-on instruction and industry tours effectively informed students of various backgrounds and identities about engineering technology.

Table 4. Difference in Student Understanding of Engineering Technology Across Demographic Groups

Participating in the Summer Bridge Program has increased my...	Male/Female p-value	ORM/URM p-value	11th/12th Grade p-value
Understanding of Types of ET Careers	0.237	1.00	0.286
Understanding of Types of ET degrees and Certifications	0.254	0.141	0.833
Understanding of Skills for ET Careers	0.428	0.348	0.171
Interest in ET Careers	0.460	0.801	0.238

*Note: *p<0.05; **p<0.01; ***p<0.001. ORM=Overrepresented Majorities, URM=Underrepresented Minorities*

Student Perceptions of ET Industry Skills

Another pivotal aspect of the summer bridge program was the industrial safety course, which is a requirement for all ET credentials, which focuses on safety standards and OSHA 10. As a part of the post-participation survey, students were asked to rate their understanding of various ET industry-related skills on a 5-point Likert Scale, both at the current time and prior to the bridge program. Using paired sample t-tests, we examined the significance of the differences between student perceptions of various ET industry-related knowledge and skills. Table 5 reports the t-values for pre/post differences for each demographic group and the full sample. Results highlight statistically significant differences between pre and post-scores across all survey items for both the full sample and each demographic subgroup. The results indicate that students perceived the SAF 130 course to be effective in educating them on some ET industry-related skills, specifically regarding OSHA regulations and workplace safety.

Table 5: T-values for Pre/Post Student Understanding of Industry-Related Skills

Participating in the Summer Bridge Program has increased my understanding of…	Male df = 20	Female df = 12	11th df = 21	12th df = 11	ORM df = 16	URM df = 16	All Sample df = 33
OSHA Safe Workplaces	3.98***	2.69*	4.16***	2.42*	3.52**	3.23**	4.84***
Personal Protective Equipment Use	3.87***	2.14	3.13**	3.07*	3.27**	2.75*	4.31***
Common Workplace Safety and Health Hazards	4.16***	3.25**	4.42***	2.89*	4.04**	3.45**	5.33***
Maintenance of Walking and Working Surfaces	3.76**	3.05*	4.11***	2.59*	3.38**	3.46**	4.88***
Identifying and Resolving Fall Hazards	4.94***	3.45**	4.55***	3.98**	3.93**	4.59***	6.09***
Identifying and Resolving Fire Hazards	4.11***	2.38*	3.18**	3.75**	3.41**	3.14**	4.67***
Emergency Action Plans	4.79***	4.22**	5.26***	3.63**	4.24***	4.67***	6.38***
Preventing Workplace Violence	4.93***	4.22**	5.11***	3.92**	4.07***	5.1***	6.49***

*Note: *p<0.05; **p<0.01; ***p<0.001. df= degrees of freedom, ORM=Overrepresented Majorities, URM=Underrepresented Minorities*

Independent sample t-tests were utilized to examine the differences in prior understanding of industry-related skills across demographic groups. Comparisons were drawn between male and female students, historically represented and underrepresented in STEM, and rising high school seniors and incoming college first-years. Results found no statistically significant differences across different demographic groups for any of the industry skills, whether in their preconceptions of the industry skills or their perceived competency after the bridge program. This indicates that students were entering the bridge program with similar levels of knowledge regarding ET industry-related skills. Through the SAF 130, all students left the bridge program with similar levels of perceived competence after the course.

Student Perceptions of College Success Skills

In addition to the course on ET industrial safety, bridge program participants also took part in a College Success Skills CDV 101 course. In alignment with the course outcomes, students answered seven survey items on their post-participation survey after the bridge program concerning the prior knowledge and perceived competence of college success skills. Paired sample t-tests were conducted across all seven survey items to examine the differences between student perceptions of their understanding of pre and post-bridge programs. Results indicated statistically significant differences between pre/post perceptions across all seven skills for the entire sample: underrepresented minority students, overrepresented majority students, rising high school seniors (11th grade), and male students. These results indicate that these subsets of students perceived the course to improve their understanding of the skill listed in Table 6. Of the 49 t-values calculated, 4 of them were not statistically significant, three from incoming first-year college students and one from female students. Incoming first-year college students indicated no significant difference in their understanding of learning styles, ability to identify their preferred learning style, and strategies for effective studying. Similarly, female participants did not statistically significantly improve their understanding of strategies for effective studying.

Table 6: T-values for Pre/Post Student Understanding of College Success Skills

Participating in the Summer Bridge Program has increased my understanding of…	Male df = 20	Female df = 12	11th df = 21	12th df = 11	ORM df = 16	URM df = 16	All Sample df = 32
Different Types of Learning Styles	3.08**	2.27*	3.36**	1.81	3.09**	2.21*	3.75***
Identifying My Own Learning Styles	2.94**	2.25*	3.17**	1.79	2.66*	2.75*	3.60***
Strategies for Managing College Work	4.36***	2.65*	3.92***	3.19*	4.04**	3.17**	5.05***
Strategies for Effective Studying	3.29**	2.00	3.60**	1.46	2.67*	2.79**	3.81***
Money Management	3.94***	2.38*	3.40**	3.07*	2.93*	3.43**	4.49***
Effective Communication Strategies	3.9***	2.42*	3.60**	2.63*	3.22**	3.09**	4.40***
Strategies to Manage Anxiety and Stress	3.24**	2.80*	3.17**	3.13*	3.34**	2.7**	4.21***

**p<0.05; **p<0.01; ***p<0.001. df = degrees of freedom, ORM=Overrepresented Majorities, URM=Underrepresented Minorities*

Discussion

The results presented above support the bridge programs' goal of improving student awareness and understanding of the engineering technology field (ET). First and foremost, results indicated that the bridge program was successfully able to recruit students that are historically underrepresented in STEM and ET fields, which was a primary goal of the program. Regardless of gender, ethnicity, race, or academic level, students entered the program with no statistically significantly different preconceptions of engineering technology and its associated skills, corroborating a general lack of student awareness of the ET field [13-14]. Additionally, across all demographic groups, results highlighted a statistically significant difference in student perceptions of their understanding of ET and ET-related skills. These results indicate that the bridge program was successful in improving student awareness of the ET field through hands-on instruction, labs, and industry tours.

Also, results showed that the students perceived their understanding of their ET industry and college success skills to improve over the bridge program, with a few notable exceptions. Specifically, incoming first-year college students indicated a lack of learning around studying strategies and learning styles. While there was no statistically significant data differentiating the pre-program understanding of learning styles between rising first-year college students (M = 3.70, SD = 0.675) and rising high school seniors (M = 3.32, SD = 1.129), there is a difference in the scores, which corroborates prior research highlighting that study habits develop with age [15]. One potential reason for the lack of significant difference is the high variance of the rising high school seniors cohort. While common in instructional practice, most research evidence suggests there is little to no benefit of learning styles on student learning. However, research suggests it possibly indicates student preference [16]. Students who are further along in their careers may have had more time to develop a preference for a learning style, or students may have already been exposed to learning styles in their high school courses prior to the bridge program.

Additionally, results indicated that female students did not significantly improve their understanding of studying habits as opposed to their male counterparts. While the pre-test for studying habits was not statistically different between male and female students, female students (M = 3.54, SD = 1.05) scores were higher than their male counterparts (M = 3.35, SD = 0.933), potentially highlighting a discrepancy in studying habits. However, prior literature is split on gender's impact on studying habits, with some literature highlighting that there is no difference across genders [15,17], with literature also highlighting that female students have better study habits [18].

Conclusion

To meet the needs of emerging technologies for an educated workforce in those technologies, high-tech manufacturing, and technician workforces require investment from higher education institutions and industry. Through intentional partnerships, we hope to broaden and diversify the STEM pipeline through programs that increase awareness of engineering technology education programs that can increase the pool of qualified candidates [1]. This research highlights several successful mechanisms within a bridge program out of NOVA to increase student awareness and understanding of ET careers to serve the surrounding area.

Due to the funding and program limitations, the bridge program was limited in the breadth of its student outreach, which we hope to increase in future iterations of the bridge program. Additionally, due to the smaller sample size, we were not able to use more robust methods of statistical analysis, such as MANOVA or multiple regression, to examine how the interactions of demographic groups influenced participants' development throughout the program. Future extensions of this research will examine student and parent preconceptions of the differences between engineering and engineering technology. Additionally, outreach to parents and partnerships with secondary institutions may further develop the pipeline for providing students with a more comprehensive view on the engineering technology careers open to them.

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