Baskin Engineering Excellence Scholars Bridge Program: Planning, Implementation, and Evaluation

Narges Norouzi *
Computer Science and Engineering
University of California Santa Cruz
Santa Cruz, USA
nanorouz@ucsc.edu

Carmen Robinson *
Office of Student Excellence, Engagement, and Inclusion
University of California Santa Cruz
Santa Cruz, USA
crobins3@ucsc.edu

Rebecca Covarrubias *
Psychology
University of California Santa Cruz
Santa Cruz, USA
rebeccac@ucsc.edu

Ruby Hernandez *
Psychology
University of California Santa Cruz
Santa Cruz, USA
ruaherna@ucsc.edu

Danay Weldegabriel *
Educational Opportunity Program
University of California Santa Cruz
Santa Cruz, USA
dweldega@ucsc.edu

Gwynn Benner *
Student Success Equity Research Center
University of California Santa Cruz
Santa Cruz, USA
gbenner@ucsc.edu

Wenjuan Sang *
University of California Santa Cruz
Santa Cruz, USA
wesang@ucsc.edu

Rafael Espericueta *
Computer Science and Engineering
University of California Santa Cruz
Santa Cruz, USA
resperic@ucsc.edu

***Abstract*—In this Research to Practice Full Paper, we intend to share our experience in design, implementation, and evaluation of a summer bridge program for a group of first-year first-generation and underrepresented students entering engineering majors at the University of California Santa Cruz. Our program is proven to prepare students for engineering programming and mathematics courses, develop a growth mindset, build self-efficacy, and bond with the cohort to build peer-mentoring opportunities and increase a sense of belonging to the campus community and our school of engineering. We describe 1) program design and goals, 2) program schedule and curriculum (mathematics and programming), 3) description of research-based program evaluation, and 4) outline of research findings (both quantitatively and qualitatively).**

I. Introduction

Over the past decade, there have been attempts to provide students from different backgrounds an exposure to foundations of Computer Science (CS) through engaging CS curricula at the high school level [1]–[3]. Examples of these attempts include Exploring Computer Science (ECS) and Advanced Placement CS Principles (AP CSP) courses [4], [5]. Despite all these efforts, minorities are more likely to be attending low-resourced schools that do not offer opportunities for high school computing [6]. Disparities in students' preparation together with different enrollment impaction policies that are in place to control the surge of interest in STEM majors seem to put these students at a special disadvantage [7].

* Authors worked on different elements of this paper (planning, implementation, and evaluation), and hence contributed equally.

Considering the disparate CS exposure in pre-college education, summer bridge programs are increasingly being developed in Science, Technology, Engineering, and Mathematics (STEM) disciplines because of the rigorous content and lower student persistence compared with other disciplines. These programs are multi-week intensive experiences in the weeks before the first year of college. Looking into the literature of research on bridge programs reveals that these programs have different characteristics concerning their goals, evaluation method(s), their success in meeting the program goals, subject of the program (across STEM or a specific major within STEM), the type of institution the program was implemented in, students admitted to the program (first-year or transfer student), program's duration (between 4 days and six weeks), and whether a peer-reviewed paper is published based on the program's implementation and evaluation.

Aside from program implementation details, program goals and methods for evaluating programs are essential. As outlined in an analysis of 25 years of STEM summer bridge programs, the main reported goals of most summer bridge programs are 1) academic success, 2) psycho-social goals, and 3) department-level goals [8]. Academic success has been translated into specific, measurable elements of students' academic progress for different programs. These academic success elements include: 1) providing students with the foundational knowledge of the STEM field [9], [10], 2) more generally, increasing students' content knowledge in a field [11], 3) improving students' GPA (compared to another controlled group), 4) increasing research preparation (which has shown promise in students' retention in STEM) [12], 5) increasing student retention [13], 6) increasing the graduation rate of students [14], and 7) decreasing time-to-degree for students. The reported psycho-social goals of the existing bridge programs include 1) improving the sense of belonging [15], 2) increase send of preparedness, 3) increasing self-efficacy [16], and 4) networking with students and faculty [17]. Lastly, the principal reported departmental-level goal is the enhance diversity in STEM majors. [18] executed several hypothesize estimations to identify how different bridge programs were able to increase diversity and retention of STEM major students.

Considering the extensive and increasing work on STEM bridge programs, we have identified some of the main goals that would address equity and retention issues for our STEM majors, and we defined our evaluation criteria for each program goal. At our institution, as across the nation, we observe four primary equity and achievement gaps in STEM: 1) female versus male, 2) first-generation (are first in their family to attend a four-year college/university) versus non-first-generation, 3) LatinX versus non-LatinX, and 4) Educational Opportunity Program (EOP) students versus non-EOP (at our institution, an EOP student is one who has been identified as having educational disadvantages via family income, first-generation status, attended historically under-performing schools, are currently in the military, were raised in a foster family, or are undocumented students). Along with many others, the authors of this paper desire to support learning, achievement, and equity across all STEM degree programs and reduce disparity indicators. This paper focuses on students pursuing Engineering majors; however, the program's design and assessment methods are transferable to other STEM programs as well.

Authors have worked with the National Center for Women Information Technology (NCWIT) to identify achievement gaps at our institution. We previously have specifically looked into the design of gateway introductory CS courses and used learning theories to eliminate achievement gaps in these courses [19]. We then looked further into identifying other elements that contribute to disparities in achievement gaps beyond course design. By looking at our institutional data, we identified the gap in students' CS and mathematics placement as an important incorporating factor in students' persistence in STEM, which is also supported in the literature [20]–[23]. In this work, the authors have designed, implemented, and evaluated our Baskin Engineering Excellence Scholars (BEES) summer bridge program (also known as engineering academy or bootcamp program in some schools) as a way to conduct an early intervention to reduce and eliminate achievement gaps in our School of Engineering.

This paper outlines the program design and goals, program curriculum (in computer science and mathematics), research-based assessment methods, and findings. We are not providing a formula for success, but instead, we are introducing a curriculum that can alleviate disparities in students' preparation. The goals and assessment methods we discuss in this paper can also be utilized when designing summer bridge programs for STEM majors at other institutions.

II. Excellence Scholars Program Design

The primary focus of our excellence scholars program is to provide resources for Under-Represented Minority students (URMs) in engineering who are eligible upon meeting two or more of the following: are first in their family to attend a four-year college/university; may have limited financial resources or experienced socio-economic challenges (low-income, financial need); are from historically underrepresented or marginalized groups who typically do not pursue engineering studies. As a retention and equity program, the aim is to learn more about the effectiveness of early intervention through the excellence scholars summer program, evaluate feedback we received from students in achieving program goals, and learn more about student needs. Our project's goals are multi-fold to improve retention and matriculation of URMs in engineering majors at the School of Engineering at the University of California Santa Cruz.

A. Program Goals

Inspired by some successful summer bridge programs [24], we designed the program with the following goals in mind:

- Preparing students for core engineering and computer science programming courses such as CS1 and CS2,
- Providing students with the required mathematics preparation for engineering majors,
- Learning to develop a growth mindset,
- Helping students build self-efficacy and confidence,
- Bonding with the cohort & peer-mentoring opportunities,
- Campus belonging.

These goals, if successfully achieved, would foster a group dynamic between all students in the cohort and create a support system for them. The curriculum we designed is also meant to create a learning environment to prepare students for placement exams or CS1/2 and mathematics courses during their Freshman year. Additionally, due to enrollment impaction policies we have in place at our institution, students need to make timely progress in mathematics and programming courses to maintain their STEM major status and be able to declare their major on time.

B. Program Implementation

Our excellence scholars summer program was hosted beginning September 13, 2020, and concluding September 26, 2020. The first day was allocated for student on-boarding and orientation, and the last two days were dedicated to introducing students to campus resources and a team-based programming hackathon. The program was delivered online through Zoom during COVID-19 remote learning, and a typical teaching day schedule was as follows:

1) Lectures: Two faculty from the CS department taught programming lectures, and a former community college mathematics professor was hired to design and teach mathematics lectures. Programming lectures were delivered using interactive online slides so students can code along with the instructors and be able to test their understanding in real-time.

2) Problem-Solving Sessions: Two graduate instructional assistant students and six undergraduate tutoring assistants were also hired to facilitate problem-solving sessions to reinforce concepts introduced in the programming and mathematics lectures. Our graduate instructional assistants would go over some sample problems with students and review the main concepts in each problem-solving session. Then, students were sent to breakout rooms to work on solving questions from a given problem set. Undergraduate tutors monitored breakout rooms to provide additional support.

3) Mentor Check-in: Each day of the program was wrapped up by students checking in with their peer-mentors or undergraduate advisors. This was meant to provide students with regular and frequent opportunities to talk to a mentor to ensure they were on the right track.

C. Curriculum

We have conducted a brief survey from students to understand the level of programming and mathematics preparation they come with and designed our curriculum to consider all preparation levels while having an eye on the competencies they need to enter their first mathematics and programming courses. Since our CS1 course is taught in Python, we designed programming lectures based on Python. The mathematics curriculum was also designed to initially go over pre-calculus topics and then build a transition to main calculus concepts. We have also included some topics that would give students a basic understanding of concepts related to the discrete mathematics course (one of our courses with the largest achievement gap in our engineering school). Details of the mathematics and programming curriculum are outlined in Table II.

9 am - 10:30 am	Programming Lecture
10:30 am - 11 am	Break
11 am - 1 pm	Programming Problem-Solving Session
1 pm - 2 pm	Lunch Break
2 pm - 3:30 pm	Mathematics Lecture
3:30 pm - 4 pm	Break
4 pm - 5:30 pm	Mathematics Problem-Solving Session
5:30 pm - 6 pm	Mentor Check-in

TABLE I: Daily schedule for the summer excellence scholar program.

Programming	Mathematics
Introduction to Python	Numbers, set theory, & functions
Variables, expressions, & operators	Solving equations & inequalities
Conditional control flow	Trigonometry
Control flow (cont.)	Solving trigonometric equations
Functions	Summation notation & Probability
Strings	Linear algebra
Lists	Intuitive calculus
Tuples & Sets	Derivative & Newton's method
Modules	Integrals
Programming wrap-up	Fundamentals of calculus

TABLE II: Program's curriculum.

III. Program Evaluation

Incoming URM students recruited and accepted into the program were surveyed before attending the summer program and post-attendance. Anticipated changes included greater student confidence regarding their mathematics and programming skills and an improved sense of belonging to the campus from working together with other similar students and learning about campus resources. The goals of the program drive the choice of methods. This program evaluation used a mixed-method design to understand students' experiences comprehensively and combined both quantitative and qualitative research methods. The quantitative data analysis helped researchers understand how students felt about mathematics, programming, their peer community, and the campus. It also provided a comparison between pre-survey and post-survey to see if any differences can be found in students before and after they participated in the program. The qualitative data analysis supplemented the survey questions and allowed us to capture the students' reactions following the completion of the program. Table III outlines the methods used to measure program goals in the pre- and post-surveys. Details of each of the methods are described in the upcoming section.

Program Goals	Assessment Method(s)
Programming preparedness	1) Academic self-description (self-concept) assessment [25] 2) Science motivation assessment [26] 3) Qualitative program's effectiveness assessment (post-survey only)
Mathematics preparedness	Same as above (adapted for mathematics)
Growth mindset	1) Growth mindset assessment [27]–[29] 2) Help-seeking assessment [30] 3) Concealment assessment [30]
Self-efficacy	1) Academic self-description (self-concept) assessment [25] 2) Science identity assessment [31], [32]
Peer community	Peer community assessment [33]
Campus belonging	Sense of belonging to campus scale [34]

TABLE III: Program goals and assessment methods.

A. Data Collection

The program evaluation used the survey data collected by the research team in Summer 2020. Two surveys were conducted before the first day of the summer program on September 12, 2020, and after the last day of the program on September 29, 2020. In both rounds, the surveys were sent out to all students by the program director via email, and students were asked to fill out the survey through a web-based, secure software Qualtrics. Both rounds used the same survey items to understand changes of students after they took the summer bridge program. In addition, the second and final survey contained open-ended questions to supplement the survey items.

B. Participants

As mentioned before, students were eligible to join our program upon meeting two or more of the following: 1) are first in their family to attend a four-year college/university; 2) may have limited financial resources or experienced socio-economic challenges (low-income, financial need); 3) are from historically underrepresented or marginalized groups who typically do not pursue engineering studies. Invitations went out to all incoming Frosh students in May and June of 2020. 43 eligible students from all engineering majors (Computer Science, Computer Engineering, Electrical Engineering, Technology and Information Management, Robotics Engineering, and CS Game Design) participated in our two-week program. Of these students, 39 completed the pre-survey, 34 completed the post-survey, and 31 students completed both. Out of all 31 students, we have obtained consent forms from 30 students to use their responses for program evaluation and assessment. This gives us a rate of response of 69.77%.
Among students in our final sample ($n = 30$), 13 (43.3%) are female and 17 (56.6%) are male. Additionally, 12 (40%) are EOP student, 15 (50%) are non-EOP, while EOP status of the remaining 3 (10%) remains unknown. All these students are first-generation students.

IV. Quantitative Assessment Methods and Findings

We have used multiple techniques to analyze program's effectiveness in each of the assessment categories listed in Table III. First, we calculated Cronbach's Alpha [35] to measure the reliability of each of the scales we used. Table IV outlines alpha values for each of the pre- and post-survey assessment categories. Cronbach's Alpha is a measure of the scale's reliability and is calculated as a function of the number of test items and the average inter-correlation among the items. A high alpha value indicates a high degree of consistency, which is what we observe in all our assessment scales.

A. Academic Self-description (Self-Concept) Assessment

The following statements were asked about students' willingness to participate in our mathematics or programming classes. Students were asked to indicate their agreement or disagreement (by selecting one of the six response categories - rated 1 through 6) [25].

- Mathematics (programming) is one of my best subjects.
- I often need help in mathematics (programming).

Construct	# of Items	Pre-Survey Alpha	Post-Survey Alpha
Mathematics Self-concept	10	0.910	0.862
Programming Self-concept	10	0.842	0.906
Science Motivation	12	0.943	0.971
Growth Mindset	3	0.946	0.909
Help-Seeking	5	0.890	0.940
Concealment	8	0.906	0.918
Science Identity	4	0.835	0.871
Peer Community	2	0.986	0.930
Campus Belonging	3	0.966	0.956

TABLE IV: Cronbach alpha values for pre- and post-survey constructs indicating a high degree of consistency in all assessment methods.

- I look forward to mathematics (programming) classes.
- I have trouble understanding anything with mathematics (programming) in it.
- I enjoy studying for mathematics (programming).
- I do badly in tests of mathematics (programming).
- I get good marks in mathematics (programming).
- I never want to take another mathematics (programming) course.
- I have always done well in mathematics (programming).
- I hate mathematics (programming).

1) Mathematics Self-Concept Outcome: We have conducted a two-way mixed ANOVA test with repeated measures [36] and observed that there does not seem to be an interaction between Gender and Time ($F(1, 0.016) = 0.295$, $p = 0.592$, $\eta^2 = 0.011$, as estimated by the Greenhouse-Geisser method [37]). There does not seem to be an interaction between EOP status and Time ($F(1, 0.000) = 0.002$, $p = 0.966$, $\eta^2 = 0.000$, as estimated by the Greenhouse-Geisser method).

We also tested main effects, since interactions were not significant. There is an overall effect of Time and it seems like students' mathematics self-concept have slightly decreased from the pre-survey ($\mu = 4.74, \delta = 0.73$) to post-survey ($\mu = 4.58, \delta = 0.48$). There was also no main effects of Gender or EOP status on mathematics self-concept. Overall, students had a positive mathematics self-concept.

2) Programming Self-Concept Outcome: We again conducted a two-way mixed ANOVA test with repeated measures and observed that there does not seem to be an interaction between Gender or EOP status and Time ($p_{gender} = 0.731$, $p_{EOP} = 0.448$). We then tested main effects since interactions were not significant. There was a main effect of gender on programming self-concept in the pre-survey and male students reported higher scores ($\mu = 4.55, \delta = 0.62$) than female students ($\mu = 4.00, \delta = 0.59$). There was not a main effect of Gender on programming self-concept in the post-survey data ($p = 0.102$). This is a great achievement since we were able to bring programming self-concept of students in both gender groups to the same level. Additionally, there was no main effects of EOP status on programming self-concept in pre-survey ($p = 0.796$) and post-survey ($p = 0.869$). Overall, students had a positive programming self-concept.

B. Science Motivation Assessment

Science motivation assessment has been done based on selecting three out of five main suggested factors for measuring students' science motivation by [26]. These factor are:

Factor 1: Intrinsic Motivation & Personal Relevance

- The science I learn is relevant to my life.
- The science I learn is more important to me than the grade I receive.
- The science I learn relates to my personal goals.
- I find learning the science interesting.
- I enjoy learning the science.
- Understanding the science gives me a sense of accomplishment.

Factor 2: Self Determination

- I put enough effort into learning the science.
- I prepare well for the science tests.
- I use strategies that ensure I learn the science well.
- If I am having trouble learning the science, I try to figure out why.

Factor 3: Career Motivation

- I think about how learning the science can help my career.
- I think about how learning the science can help me get a good job.

These three science motivation factors can inform us about interventions we can employ to help students persist in STEM majors. Figure 1 illustrates students' self-reported science motivation in each of the three categories. As shown here, our EOP students start the program with less motivation in all three categories than their non-EOP peers; however, their science motivation concerning intrinsic motivation and self-determination persisted at around the same range, and their career motivation accelerated in the post-survey data. More investigation is still needed to see why some students reported less motivation in their post-survey responses. We anticipate that the short duration of the program and the condensed materials covered over the two weeks might be among the incorporating factors.

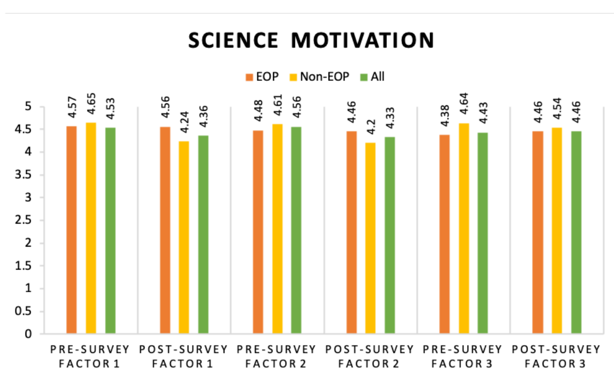

Fig. 1. Analysis of the effect of the program on students' self-reported science motivation, separated by EOP status. The scale is from 1 (lowest motivation) to 5 (highest motivation).

C. Growth Mindset Assessment

We have used implicit theory of intelligence scale [27] in assessing students growth versus fixed mindset approaches. Items included [28], [29]:

- You can learn new things, but you cannot really change your basic intelligence.
- Your intelligence is something about you that you can't change very much.
- You have a certain amount of intelligence and you really can't do much to change it.

Figure 2 outlines the changes in the 3-item growth mindset evaluation of all students and its distribution based on different self-identified gender groups. As can be seen, the growth mindset has been improved overall for all students (scales are in reverse order, higher values correspond to a fixed mindset, and smaller values indicate growth mindset). We also observed that female students started the program with a weaker growth mindset indicator than their male peers; however, their average growth mindset scores showed more significant improvements in all three categories.

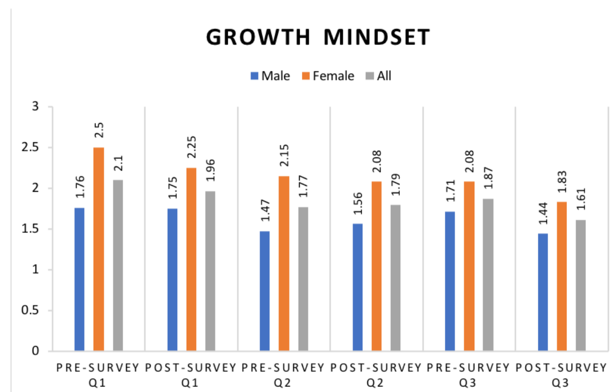

Fig. 2. The 3-item growth mindset evaluation in pre- and post-survey, separated by gender groups.

D. Help-seeking Assessment

Students approaches to help-seeking behavior were assessed based on the following questions [30]:

- When I have trouble with a STEM subject in school...

1) I ask for help understanding the material.
2) I get some help to understand the material better.
3) I ask the teacher to go over it with me.
4) I ask the teacher to explain what I didn't understand.
5) I get some help on the parts I didn't understand.

Looking into the pre- and post-survey data, we have not observed any significant changes in students' help-seeking behavior. Our students continued to receive tutoring services throughout the academic year from our Mathematics, Engineering, Science Achievement (MESA) program. We are currently looking into measuring students' help-seeking approach after receiving these quarterly tutoring services.

E. Concealment Assessment

As one of the factors in measuring students growth mindset, we asked students to answer to the following questions related to their tendency to conceal their problems [30]:

• When something bad happens to me in school (such as not doing well on a test or not being able to answer an important question)...

1) I stay away from people.
2) I don't want to see anyone.
3) I don't want to talk to anyone about it. I don't want to talk about it.
4) I try to keep people from finding out.
5) I make sure nobody finds out.
6) I try to hide it.
7) I don't tell anyone about it.

We observed no significant difference in students' overall tendency to concealing their problems ($\mu_{pre} = 1.87$, $\mu_{post} = 1.88$). We also observed that female students and non-EOP status students tend to conceal problems more compared to male students and students with EOP status, respectively. The average concealment tendency of both groups (female and non-EOP status students) has improved after the program.

F. Science Identity Assessment

To understand students experience and sense of belonging to STEM, students were asked to respond to the following statements by choosing from categories "strongly disagree" to "strongly agree" (coded 1 – 6) [31], [32].

- In general, being a (Science, Technology, Engineering, Mathematics) STEM scientist is an important part of my self-image.
- I have a strong sense of belonging to the community of STEM scientists.
- Being a STEM scientist is an important reflection of who I am.
- I have come to think of myself as a 'STEM scientist'.

Figure 3 illustrates the impact of the program on students' science identity and hence their self-efficacy in STEM. As shown below, we observe consistent improvements in students' self-reported science identity for all students. This trend persists when looking into specific student sub-groups (gender and EOP status). It is also worth noting that the average science identity score for female students coming to the program is considerably higher than their male peers, yet it increases even more after attending the program. It is, therefore, imperative to reinforce and empower the positive self-image throughout our lower-division and upper-division curriculum to eliminate the gender achievement gap in STEM majors. Another positive note is the program's impact on EOP students, which improved their average science identity score beyond the cohort's average score.

G. Peer Community & Campus Belonging Assessment

The following questions were asked to understand whether the program was successful in building a community amongst our URM students [33], [34].

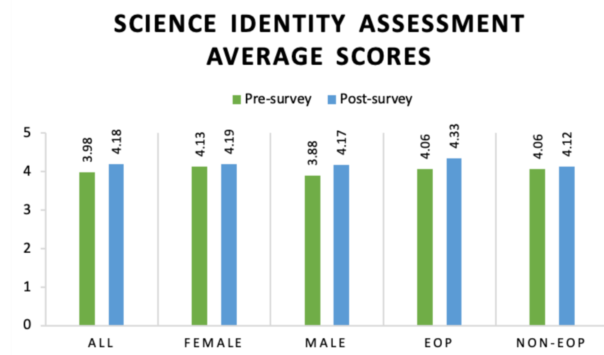

Fig. 3. Average science identity scores of the pre- and post-survey data for all students as well as different student sub-groups.

• Peer community questions:

1) I anticipate feeling connected to my peers in the school of engineering community.
2) I anticipate feeling connected to my peers around me at BEES.

• Campus belonging questions:

1) I see myself as part of the campus community.
2) I feel that I am a member of the campus community.
3) I feel a sense of belonging to my campus.

Based on the survey results, most of our students (97%) felt that they are connected to their peers in the engineering school and in our campus. Additionally, students sense of belonging to the campus community have improved from 90% to 97% after the program.

H. Discussion: Correlation Between Assessment Scales

To analyze the validity of the evaluation we have conducted on the program through pre- and post-survey data, we calculated the Cronbach's alpha of both surveys. The Cronbach's alpha of the pre-survey is 0.79 and is improved to 0.83 for the post-survey data. This indicates a good overall reliability of the survey questionnaires. Additionally, we looked into the correlation between different assessment categories in the post-survey data. Results are listed in Table V and significant correlations are highlighted.

Based on the correlation results shown in Table V, students who had high programming self-concept were less likely to hide their problems and difficulties and more likely to have a growth mindset. These students also feel stronger belonging to their peer community and campus, and know more about campus resources.

V. Qualitative Assessment and Findings

Open-ended questions were added to the post-program assessment in order to be able to conduct inductive thematic analysis [38] and identify specific items about the program that can be improved. These questions were used in the academic preparedness, peer community, and program's overall effectiveness evaluation. Free-response questions were:

	Mathematics self-concept	Programming self-concept	Science motivation	Growth mindset	Help-seeking	concealment	Science identity	peer community	campus belonging
Mathematics self-concept	1	0.08	0.2	0.08	0.25	-0.13	0.36	0.25	0.29
Programming self-concept	-	1	0.27	0.5^{**}	0.17	-0.5^{**}	0.2	0.46^{*}	0.39^{*}
Science Motivation	-	-	1	0.27	0.4^{*}	-0.24	0.42^{*}	0.31	0.26
Growth Mindset	-	-	-	1	0.33	-0.34	0.37^{*}	0.47^{**}	0.46^{**}
Help-Seeking	-	-	-	-	1	-0.05	0.15	0.41^{*}	0.44^{*}
Concealment	-	-	-	-	-	1	0.05	-0.28	-0.28
Science Identity	-	-	-	-	-	-	1	0.33	0.26
Peer Community	-	-	-	-	-	-	-	1	0.7^{***}
Campus Belonging	-	-	-	-	-	-	-	-	1

TABLE V: Correlation between different assessment scales ($*: p < 0.05$, $**: p < 0.01$, $***: p < 0.001$).

- How do you feel about navigating social connections (with peers, staff, and faculty) at BEES?
- How comfortable do you feel connecting with others (peers, staff, faculty) at BEES? Do you have any concerns about forming connections?
- In what ways, if at all, were your parents or other family members supportive of your attending the BEES summer academy?
- Are there other forms of support that you wish your parents or other family members could provide?
- What was the highlight of your experience in the Summer academy?
- What was the most challenging part of your experience in the Summer Academy? How did you deal with this?
- In what ways did Summer Academy help you?
- In what ways was the academy not helpful to you? What would have been more helpful?
- Is there anything else that you would like to share with us that we did not ask or missed?

For qualitative analysis purpose of this paper, we are only focusing on the last five questions that were specific to the program's overall effectiveness.

A. Highlights of the program

Respondents reported equally the highlight of their time was the opportunity to prepare for classes and socialize with others. Respondents who enjoyed the preparation and review of classes (27.27%) made comments such as, "Bring me back to pace after a long summer before school starts was very helpful." Respondents who highlighted socializing and meeting others (peers, tutors, faculty) (27.27%), reported, "I'd say the highlight of my experience in the BEES Summer academy was the community we had with the group we were in and the social interactions with our instructors and mentors" and, "The highlight of my experience of this academy is meeting and talking to new people. Where I wouldn't have if I didn't do this program." Another large portion of respondents mentioned learning something new was the highlight of their experience (25%), for example, "Learning python for the first time was the highlight of my experience." The final highlight mentioned by respondents involved comments about the content or format of the program (20.45%), such as, "The highlight of the BEES program would be the support sessions. I feel like I was more comfortable with small groups."

B. Challenging parts of the program

The most common challenge students encountered was difficulty with content or concepts outside their comfort zone (50%). For example, one respondent mentioned circumstances such as, "Retaining new information. Going from beginner to advanced. Got through." A little over a quarter of respondents mentioned challenges with staying focused or motivated throughout the program (26.47%), such as, "Not pushing self enough to understand new material. Learned to be okay with process." A less common challenge that was noted was personal concerns involving issues with the online format or a shifting perception throughout the program (11.76%), such as, the "Online format, feel do better in person," and "Unsure of programming results early in academy. Second week more comfortable to talk peers about results."

C. Helpfulness of the program

More than half of respondents mentioned that receiving preparation for college through our program was very helpful (64.81%). Many mentioned appreciating the preparation for classes, meeting people to ease the transition and introduction to college level content, for example, "Prepar[a]tion for college-level math/programming and getting used to learning online." A quarter of respondents also mentioned they received help learning new skills and reviewing others that were a mixture of practical, interpersonal, and academic (25.93%), such as this respondent who learned skills that can serve them well in college, "Importance of adequate rest, preservering in tough times for: new skills, friendships, connections," and this respondent who learned about gaps in knowledge, "Learn new material helpful for fut[u]re classes. Ahead of others with no programming experience." A few mentioned that he program provided them with more confidence as they entered college (9.26%; "More confident in taking class in Fall.")

D. Improvements on helpfulness

The majority of respondents could find nothing wrong with the helpfulness of the program (48.39%), such as this positive response to this question, "Absolutely helpful, changed any second thoughts, enjoyed time." Other students noted areas that they found more helpful than others and asked for more time on certain content (e.g. math), more breaks, or wanted more in-person interaction (41.94%), such as, "More breaks to absorb information not get overwhelmed. [...]." Overall, respondents were positive about the helpfulness of the program.

They appreciated the preparation that they were receiving across various dimensions that include: learning on an online format; learning relevant material for courses; meeting new people; and confidence that they are starting their college careers strongly.

VI. Conclusion

This paper discusses our two-week summer bridge program for incoming URM first-generation engineering students with a curriculum that prepares students for transitioning into college-level mathematics and programming courses while building a growth mindset and improving their self-efficacy. We describe our pilot implementation of the curriculum along with the quantitative and qualitative assessment of program goals. Our findings include improvement in students' science identity, science motivation, growth mindset, and their reported higher self-efficacy in mathematics and programming.

References

[1] R. Santo, L. A. DeLyser, J. Ahn, A. Pellicone, J. Aguiar, and S. Wortel-London, "Equity in the who, how and what of computer science education: K12 school district conceptualizations of equity in 'cs for all'initiatives," in *2019 Research on Equity and Sustained Participation in Engineering, Computing, and Technology*, 2019.

[2] J. Margolis, J. J. Ryoo, C. D. Sandoval, C. Lee, J. Goode, and G. Chapman, "Beyond access: Broadening participation in high school computer science," *ACM Inroads*, 2012.

[3] J. Margolis and J. Goode, "Ten lessons for computer science for all," *ACM Inroads*, 2016.

[4] J. Goode, G. Chapman, and J. Margolis, "Beyond curriculum: the exploring computer science program," *ACM Inroads*, 2012.

[5] A. Arpaci-Dusseau, O. Astrachan, D. Barnett, M. Bauer, M. Carrell, R. Dovi, B. Franke, C. Gardner, J. Gray, J. Griffin *et al.*, "Computer science principles: analysis of a proposed advanced placement course," in *Proceeding of the 44th ACM technical symposium on Computer science education*, 2013.

[6] J. Cuny, "Transforming high school computing: A call to action," *ACM Inroads*, 2012.

[7] T. Camp, W. R. Adrion, B. Bizot, S. Davidson, M. Hall, S. Hambrusch, E. Walker, and S. Zweben, "Generation cs: the growth of computer science," *ACM Inroads*, 2017.

[8] M. Ashley, K. M. Cooper, J. M. Cala, and S. E. Brownell, "Building better bridges into stem: A synthesis of 25 years of literature on stem summer bridge programs," *CBE—Life Sciences Education*, 2017.

[9] C. Cairncross, S. A. Jones, Z. Naegele, and T. VanDeGrift, "Building a summer bridge program to increase retention and academic success for first-year engineering students," 2015.

[10] S. B. Nite, R. M. Capraro, M. M. Capraro, G. D. Allen, M. Pilant, and J. Morgan, "A bridge to engineering: A personalized precalculus (bridge) program," in *2015 IEEE Frontiers in Education Conference*, 2015.

[11] H. M. Doerr, J. B. Ärlebäck, and A. Costello Staniec, "Design and effectiveness of modeling-based mathematics in a summer bridge program," *Journal of Engineering Education*, 2014.

[12] K. J. Graham, E. J. McIntee, A. F. Raigoza, M. A. Fazal, and H. V. Jakubowski, "Activities in an s-stem program to catalyze early entry into research," *Journal of Chemical Education*, 2017.

[13] D. L. Tomasko, J. S. Ridgway, S. V. Olesik, R. J. Waller, M. M. McGee, L. A. Barclay, and J. Upton, "Impact of summer bridge programs on stem retention at the ohio state university," in *Proceedings of the 2013 ASEE North-Central Section Conference, Washington, DC: American Society for Engineering Education*, 2013.

[14] R. L. Kopec and D. A. Blair, "Community for achievement in science, academics, and research: The casar project," in *6th Annual First Year Engineering Experience Conference, held August*, 2014.

[15] D. L. Tomasko, J. S. Ridgway, R. J. Waller, and S. V. Olesik, "Association of summer bridge program outcomes with stem retention of targeted demographic groups." *Journal of College Science Teaching*, 2016.

[16] B. C. Bruno, J. L. Wren, K. Noa, E. M. Wood-Charlson, J. Ayau, S. L. Soon, H. Needham, and C. A. Choy, "Summer bridge program establishes nascent pipeline to expand and diversify hawai'i's undergraduate geoscience enrollment," *Oceanography*, 2016.

[17] L. Lenaburg, O. Aguirre, F. Goodchild, and J.-U. Kuhn, "Expanding pathways: A summer bridge program for community college stem students," *Community College Journal of Research and Practice*, 2012.

[18] B. C. Bradford, M. E. Beier, and F. L. Oswald, "A meta-analysis of university stem summer bridge program effectiveness," *CBE—Life Sciences Education*, 2021.

[19] L. Tracy, N. Narges, R. Carmen, and Q. Jenny, "Successful interventions to eliminate achievement gaps in stem courses," in *2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology*, 2020.

[20] G. Archer, B. Bettin, L. Bohmann, A. Carter, C. Cischke, L. M. Ott, and L. Ureel, "The impact of placement strategies on the success of students in introductory computer science," in *2017 IEEE Frontiers in Education Conference*, 2017.

[21] G. Archer, L. Bohmann, A. Carter, C. Cischke, L. M. Ott, and L. Ureel, "Understanding similarities and differences in students across first-year computing majors," in *2016 IEEE Frontiers in Education Conference*, 2016.

[22] J. R. Reisel, M. Jablonski, H. Hosseini, and E. Munson, "Evaluation of factors affecting the success of improving math course placement for incoming freshmen in a summer bridge program," in *Proceedings of the American Society for Engineering Education Annual Conference*, 2010.

[23] J. R. Reisel, M. Jablonski, A. Kialashaki, E. Munson, and H. Hosseini, "Analysis of the impact of participation in a summer bridge program on mathematics course performance by first-semester engineering students," *age*, 2014.

[24] W. C. Lee, C. Wade, and C. Amelink, "Examining the transition to engineering: A multi-case study of six diverse summer bridge program participants," in *121st ASEE Annual Conference & Exposition*, 2014.

[25] H.-L. Tuan*, C.-C. Chin, and S.-H. Shieh, "The development of a questionnaire to measure students' motivation towards science learning," *International journal of science education*, 2005.

[26] M. C. Jackson, G. Galvez, I. Landa, P. Buonora, and D. B. Thoman, "Science that matters: The importance of a cultural connection in underrepresented students' science pursuit," *CBE—Life Sciences Education*, 2016.

[27] D. Da Fonseca, S. Schiano-Lomoriello, F. Cury, F. Poinso, M. Rufo, and P. Therme, "Validation study of the implicit theories of intelligence scale," *L'encephale*, 2007.

[28] C. S. Dweck, *Mindset: The new psychology of success*, 2008.

[29] ——, *Self-theories: Their role in motivation, personality, and development*, 2013.

[30] G. Marchand and E. A. Skinner, "Motivational dynamics of children's academic help-seeking and concealment." *Journal of Educational Psychology*, 2007.

[31] D. M. Young, L. A. Rudman, H. M. Buettner, and M. C. McLean, "The influence of female role models on women's implicit science cognitions," *Psychology of Women Quarterly*, 2013.

[32] M. M. Chemers, E. L. Zurbriggen, M. Syed, B. K. Goza, and S. Bearman, "The role of efficacy and identity in science career commitment among underrepresented minority students," *Journal of Social Issues*, 2011.

[33] L. A. Jason, E. Stevens, and D. Ram, "Development of a three-factor psychological sense of community scale," *Journal of community psychology*, 2015.

[34] S. Hurtado and D. F. Carter, "Effects of college transition and perceptions of the campus racial climate on latino college students' sense of belonging," *Sociology of education*, 1997.

[35] J. M. Bland and D. G. Altman, "Statistics notes: Cronbach's alpha," *Bmj*, 1997.

[36] L. St, S. Wold *et al.*, "Analysis of variance (anova)," *Chemometrics and intelligent laboratory systems*, 1989.

[37] H. Abdi, "The greenhouse-geisser correction," *Encyclopedia of research design*, 2010.

[38] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative research in psychology*, 2006.