Strengthening Academic Readiness through a Collaborative Summer Bridge for HBCU Computing Students (Work in Progress)

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Abstract

The recruitment and retention of women and underrepresented minorities remain a challenge in computing-related majors. Many students at Historically Black Colleges and Universities (HBCUs) enter computing with limited exposure to programming and without access to learning communities that encourage persistence. To address this gap, this research explores how an intercollegiate, learning community-based intervention can prepare students academically and increase a sense of belonging among students in computing-related majors.

As part of the HBCU Learning Community-based Intervention in Computing (HBCU LCI-CS), the Collaborative Bridge Program provides students with foundational instruction in computer science and mathematics, along with workshops focused on study skills, time management, and navigating college resources. The program is a collaboration among six HBCUs. This multi-campus initiative combines virtual and in-person engagement to support students before they begin their first year of college.

The bridge program is built on a learning-community model that provides HBCU students and faculty with a setting to come together and prepare for the first-year experience. Through shared academic and social activities, the program promotes collaboration, confidence, and a sense of belonging. Its design aims to strengthen students' technical and math skills while building relationships and increasing self-efficacy, which is critical to success in computing-related fields.

Evaluation instruments included pre- and post-assessments to track growth in computing and math knowledge, as well as surveys to assess self-efficacy, confidence, and belonging. Preliminary results from recent cohorts show increased performance on math and computing assessments, greater confidence in coding, and a stronger sense of belonging.

Early results suggest that being part of a collaborative, learning community-based summer bridge program can enhance academic preparation for underrepresented students in computing. Future work includes examining long-term retention outcomes and integrating lecture series and service-learning components during the academic year.

1 Introduction

The recruitment and retention of women and underrepresented minorities continue to be a challenge in computer science [1]. Recent disruptions to higher education have placed these students at a greater risk of dropping out because many struggled to remain socially connected during extended periods of remote learning. As a result, students' sense of belonging was negatively affected, making post-pandemic efforts to support engagement and persistence especially important [2].

Studies have associated the presence of a STEM identity with interest and persistence in STEM education and careers [3]. Prior research has demonstrated identity as a critical factor in the disproportionality of women and Black, Latinx, and indigenous individuals in STEM fields. For example, studies have demonstrated that women with a strong STEM identity exhibit greater persistence in STEM disciplines [4]. Similarly, students at Historically Black Colleges and Universities (HBCUs) with a strong STEM identity are more likely to enter science-related occupations following graduation [5].

This work-in-progress examines whether a learning community-based summer bridge program can support the first year for computing majors by preparing them for a successful college education through reinforcing their prior knowledge in CS and mathematics. This project targets incoming underrepresented minority freshmen student populations in computing fields to develop, prepare, retain, and ultimately increase diversity in the computing workforce.

The following sections describe the design and implementation of the community-based bridge program developed across multiple HBCUs. The program's evaluation approach and early findings are discussed to examine how participation in the bridge program supports academic preparation and sense of belonging for entering first-year computing students.

2 Background

The recruitment and retention of women and students from historically underrepresented racial and ethnic groups in computer science and other STEM disciplines remain persistent challenges. Prior research has documented structural barriers that limit access, preparation, and long-term persistence for these populations, particularly during the transition into college-level STEM programs. Summer bridge programs have been widely studied as an intervention to address these challenges, with evidence showing improvements in academic preparation, transition to college, and persistence for underrepresented students [1, 2, 3, 5]. At the same time, researchers have noted that summer bridge programs face ongoing challenges related to scalability, institutional support, and sustaining student engagement beyond the initial program period [4].

The COVID-19 pandemic further intensified existing inequities in computing education. Women and underrepresented minority students have experienced heightened risks of disengagement and attrition due to remote learning environments and reduced opportunities for peer interaction and informal community building. Prior work has shown that the pandemic negatively affected computing students' sense of belonging, a factor strongly associated with persistence and success in STEM disciplines [6]. These findings underscore the importance of post-pandemic interventions that intentionally support both academic success and social integration.

A growing body of literature highlights the importance of STEM identity in shaping students' interest, persistence, and career aspirations in STEM fields. Students who develop a strong STEM identity are more likely to persist through challenges and pursue STEM-related careers. In the research, STEM identity is reflected through measures of confidence in computing, sense of belonging and self-perception as a computing student. The Collaborative Bridge Program is intentionally designed to address the three dimensions of science identity identified by [7]: Competence, Performance, and Recognition. Specifically, competence is measured through confidence in coding and math skills, performance through demonstrated problem-solving ability, and recognition through students' self-identification as computing or STEM participants. While the technical workshops build students' competence and their ability to perform computing tasks, the learning-community model addresses the 'fragile' nature of recognition for underrepresented groups. By connecting students with faculty and peers across six HBCUs, the program creates an environment where students' bids for recognition are validated rather than disrupted. This approach aligns with the National Academies of Sciences, Engineering, and Medicine's [8] recommendations for diverse mentoring networks and Hoffman et al.'s [9] framework for fostering a sense of belonging through valued involvement. Summer bridge programs that emphasize community building, mentorship, and structured academic support have been shown to positively influence first-year persistence and performance, particularly for students from open-admissions or under-resourced educational backgrounds [5, 10]. More recent work has demonstrated that remote and hybrid bridge models can continue to support student engagement and access when in-person programming is limited, although careful design is required to maintain meaningful connection and support [6, 11].

Recent studies have also explored the integration of service learning and community partnerships into bridge and early undergraduate experiences as a means of broadening participation in computing. These approaches provide students with opportunities to apply technical skills to socially relevant problems, fostering a sense of purpose, belonging, and professional identity. Service-learning-based models have shown promise in supporting underrepresented students' engagement and persistence in computing by connecting coursework to real-world impact and community needs [12, 13]. Collectively, prior research suggests that intentional, identity-centered interventions, particularly those implemented through summer bridge programs, hybrid delivery models, and service-learning frameworks, play a critical role in supporting the success and retention of women and underrepresented students in computer science.

The concept of learning communities dates back to 1927 at the University of Wisconsin, originally implemented as a six-year program, though the term has since evolved to encompass a range of educational models and approaches [14]. Generally, learning communities are designed to intentionally connect students' academic experiences with increased interaction and collaboration among peers and faculty, fostering a shared sense of purpose and community. While learning communities have been extensively studied across higher education, limited research has examined their application within computer science education, particularly with respect to their impact on underrepresented students. In this project, we address this gap by developing an intercollegiate learning community that brings together HBCU students and faculty to support academic preparation and community building as students transition into their first year of computing-related majors.

Building on this body of work, this study responds to gaps in the literature by examining an intercollegiate learning community-based summer bridge program designed specifically for computing students at HBCUs. By combining foundational academic preparation, structured community building, and cross-institutional collaboration within a hybrid delivery model, the program seeks to support both academic readiness and sense of belonging during the critical transition into the first year. The following sections describe the design and implementation of the Collaborative Bridge Program and outline how its learning community framework was operationalized across multiple HBCU campuses.

3 Program Description

The project team developed a collaborative summer bridge program designed to prepare incoming students for computing-related majors through foundational coursework and structured academic support. The Collaborative Bridge Program is implemented through a partnership among six Historically Black Colleges and Universities (HBCUs): the University of the District of Columbia, Florida A&M University, Hampton University, Mississippi Valley State University, Norfolk State University, and Winston-Salem State University. The program includes pre-calculus and calculus preparation, introductory programming workshops, and a virtual kickoff meeting that incorporates common workshops on time management and study skills across all partner institutions. Participants are students who have been accepted to a participating institution and plan to enroll in computer science or a related major in the fall.

The primary objectives of the bridge program are to (1) create a multi-HBCU learning community, (2) support students' transition into college-level computing and mathematics, and (3) strengthen academic and non-cognitive skills critical to first-year success. Program activities include establishing a virtual learning community across institutions, delivering foundational pre-calculus and programming workshops, and implementing structured time management and study skills workshops.

The objectives are designed to support the components of STEM identity. Activity 1: Multi-HBCU Virtual Learning Community promotes belonging through peer and faculty interaction. The foundational workshops in Activity 2 support technical skill development through early, structured exposure to coding and mathematics. The time management and study skills workshops in Activity 3 support academic self-efficacy and identity formation by helping them learn expectations of college-level STEM learning.

Students are recruited through admissions, academic advising, and computing departments at each university. Incoming first-year students who are admitted to the university and have declared a computing-related major are eligible. There is no cost to students, and program expenses are supported through external grant funding.

3.1 Activity 1: Multi-HBCU Virtual Learning Community

The Multi-HBCU Virtual Learning Community establishes an HBCU intercollegiate network of students through a kickoff event followed by a series of regularly scheduled virtual engagements. These activities are designed to reinforce cohort development and sustain engagement among participants across institutions. The kickoff event serves as the foundation of community-building, incorporating interactive activities and invited guest speakers who highlight the breadth of computer science and its career pathways. Subsequent meetings reinforce these connections by providing opportunities for collaboration, peer support, and continued exposure to the field.

3.2 Activity 2: Foundational Academic Workshops

Foundational pre-calculus and introductory programming workshops are offered during the summer prior to students' first semester. Students enroll in an introductory computer science workshop that emphasizes problem-solving and algorithmic development. A mathematics component focused on strengthening pre-calculus or calculus readiness is also included. Prior research has shown that many students are unsuccessful in their initial college-level mathematics courses [15]. This summer's preparation is intended to provide an early and supportive mathematics experience that improves readiness and confidence before the academic year begins.

3.3 Activity 3: Time Management and Study Skills Workshop

Students participate in a one-week, online workshop on time management and study skills that is common across all partner institutions. Time management and study skills have been identified in the literature as persistent areas of concern for entering college students for nearly two decades [16]. Cole's synthesis of nine studies indicates that students who enter higher education without a clear understanding of academic expectations experience increased difficulty integrating into college and developing an academic identity [17]. In addition to academic preparation, the workshop addresses college success skills such as working in groups and effectively using institutional resources, including faculty office hours, teaching assistant-led study sessions, academic advising, counseling and health services, and tutoring centers

3.4 Program Strengths, Limitations, and Implementation Challenges

The design of the Collaborative Bridge Program presents several strategic strengths while also introducing implementation considerations and constraints. Key strengths of the project include multi-institution HBCU collaboration. Participants are exposed to many students in similar degree programs as well as faculty role models who look like them, factors known to support belonging and persistence. Additionally, the summer bridge program enables early intervention through instruction and workshops on math, coding, and the expectations of campus life. The bridge program provides an opportunity to interact early with students who may have limited preparation in mathematics and little or no exposure to coding. It also assists students in recalling math concepts learned in their early years of high school preparation and provides an early introduction to computing concepts, thus increasing the potential to retain students in their freshman year.

Although students benefit from the bridge program, the duration of the program is limited to at most six weeks, which restricts the depth of skill development and reduces sustained engagement. Additionally, the program's cross-institutional activities are conducted virtually, which may weaken opportunities for peer networking and relationship building compared to in-person interaction. A challenge to the bridge program has been that some students have chosen not to participate due to competing summer opportunities with financial incentives, suggesting that the program may need to consider stipends or additional support to remain competitive.

4 Implementation

The Collaborative Summer Bridge Program was designed and implemented as a multi-institutional intervention that combined shared virtual experiences with locally administered academic preparation activities. Consistent with the project design, the program targeted students who had been admitted to a participating institution and planned to enroll in computer science or closely related majors in the upcoming fall semester. The overall structure integrated foundational mathematics and programming preparation with academic success workshops to support students' transition into computing pathways.

A total of 65 students from six HBCUs participated in the LCI-CS Summer Bridge Program during Summer 2024. Participation varied across institutions, with the largest number of students from Hampton University (N = 29) and the smallest from Winston Salem State University (N = 3). At the institutional level, participating universities implemented summer bridge programs ranging from three to four weeks in length, with variations in format including residential and non-residential models.

As outlined in the project design, students participated in foundational pre-calculus or calculus preparation and introductory programming workshops that emphasized problem solving and algorithmic thinking. These academic components were designed to strengthen early math and computing readiness, addressing well-documented barriers to success in introductory college mathematics courses [15]. Local campuses aligned these academic activities with the joint virtual sessions to provide a cohesive bridge experience.

A central component of the collaborative model was the creation of a multi-HBCU virtual learning community. Partner institutions jointly hosted a virtual kickoff event followed by a series of structured online meetings. For the 2024 cohort, the joint sessions were held from July 8 to July 12, with a similar structure implemented for the 2025 cohort. Sessions were conducted for approximately one to one and a half hours per day and focused on cohort development, academic transition, and community building. The kickoff event featured interactive activities and invited talks that highlighted the breadth of computing disciplines and potential career pathways, reinforcing students' identification with the field.

Faculty, staff, and current students were intentionally integrated into the program to support acclimation to both the intercollegiate and local university learning communities. Faculty from across the partner institutions facilitated workshops and served as guest speakers, while upper-division students and, where applicable, transfer students served as peer tutors and teaching assistants. This structure supported early faculty-student and peer-to-peer connections, which have been shown to positively influence persistence among underrepresented students in computing [18]. Participants engaged in mentorship interactions with faculty and student leaders throughout the summer experience.

The joint virtual sessions incorporated structured breakout activities in which students worked in small, intercollegiate groups. These sessions supported collaborative engagement and culminated in short computing-related presentations, reinforcing communication skills and confidence in discussing technical concepts. Faculty and peer mentors rotated among breakout groups to provide guidance and feedback, further strengthening cross-campus connections.

In addition to academic preparation, the program implemented a one-week virtual workshop series focused on time management and study skills that were common across all partner institutions. As outlined in the proposal, these workshops addressed students' understanding of academic expectations, effective study strategies, working in groups, and the use of campus support resources such as office hours, tutoring centers, academic advising, and counseling services. Time management and study skills have been identified in the literature as persistent areas of concern for incoming college students, particularly for those who are uncertain about academic expectations and the development of an academic identity [16, 17].

Recruitment and selection were conducted locally by each institution using established admissions and bridge program pipelines. Participation in the collaborative bridge program was provided at no cost to students, with financial support covered through institutional and grant funding. While local program components varied across campuses, the joint virtual experience and core academic success workshops were consistent for all participants. Academic advisors played an ongoing role by supporting students' transition into fall coursework and connecting bridge participants to institutional resources, extending the impact of the program beyond the summer period.

4.1 Institution-Specific Implementation

An important aspect of this project is how the collaborative bridge program was implemented across participating institutions. While all campuses participated in the one-week joint virtual sessions, institutions varied in how they structured their local bridge programming. Specifically, institutions differed in the design and delivery of their local programming. Two primary models emerged: a course-driven or a boot-camp–style approach. These variations reflect differences in institutional priorities, student demographics, and existing summer programming. Preliminary observations indicate that both models supported gains in student preparedness and confidence.

The course-driven model emphasized enrollment in structured, often credit-bearing academic courses aligned with computing pathways. This approach allows students to engage deeply with disciplinary content while also earning academic credit. In contrast, the boot-camp model emphasized rapid immersion, offering intensive, short-term programming focused on acclimating students to campus life, academic expectations, and foundational computing concepts. This model emphasizes transition readiness, helping students quickly build confidence and familiarity with the college environment.

In addition to variation in program models, many students participated concurrently in other academic or enrichment programs during the summer, either alongside or outside of the collaborative bridge program. Rather than viewing this overlap as a limitation, it provides insight into the importance of coordination both within institutions and across the broader HBCU ecosystem to support students navigating multiple opportunities during the transition to college.

For example, at one university, the summer bridge program included 14 incoming First-Time-in-College (FTIC) students who expressed interest in computing disciplines within the Department of Computer and Information Sciences. These students intend to major in Computer Science, Computer Information Systems, Information Technology, or Cybersecurity. Although students were not enrolled in a formal mathematics course, they participated in targeted math sessions designed to prepare them for the assessment, which determines mathematics placement for the upcoming fall semester. In addition to developing foundational programming, problem-solving, and logical reasoning skills, students received training in research practices, academic writing, and strategies for "surviving and thriving" in academia as they prepared for professional careers. In one of the bootcamp-style courses, students participated in an intensive, immersive experience integrating mathematics and computer science. During the summer, the university administers a math placement exam to all students to determine fall mathematics course placement, which in turn influenced placement in their first computer science course. This assessment was administered before and after the math immersion to evaluate changes in student readiness. In addition, students engaged in C++ programming to develop foundational coding and problem-solving skills. Additionally, students are involved in college readiness activities.

5 Evaluation Approach

The participating HBCUs, in collaboration with an external evaluator, are conducting a mixed-methods implementation and outcomes evaluation that uses both qualitative and quantitative data to examine implementation fidelity and student outcomes. The evaluation, based in the CIPP model (Context, Input, Process, and Product) [19] is aligned with the grant's key objectives and is guided by the following evaluation questions:

- **EQ1:** Do the project's learning community–based programs affect participating underrepresented minority students' preparedness for a computer science or computer-related major?
- **EQ2:** Do the project's learning community–based programs affect participating underrepresented minority students' retention in a computer science or computer-related major during their first year of college?
- **EQ3:** Does participation in a broader HBCU learning community affect project participants' attitudes, confidence, and sense of belonging toward computing and computer-related fields?

While this paper focuses on evaluation questions most directly related to the summer bridge component, the broader project evaluation includes additional questions related to other intervention components and overall project implementation. These include examining whether service-learning increases participating underrepresented minority students' motivation and engagement in computing-related majors; assessing the extent to which project implementation aligns with the Common Guidelines for Education Research and Development; evaluating how grant design, research, and development activities are planned and implemented relative to anticipated progress toward project goals; and exploring the project's potential for broader impacts.

Evaluation of programming that continued throughout the academic year included additional observations, student focus groups, PI focus groups, collection of student outcome data (e.g., GPA, grades in computing courses, and persistence), and administration of a final post-survey.

To answer these questions specifically about the bridge program (additional tools are used to evaluate the school-year program components), the evaluation included pre- and post- mathematics and computing assessments, a pre- and post-student survey, program observations, and interviews with PIs.

5.1 Summer Bridge Mathematics and Computing Assessments

Project investigators collaboratively developed pre- and post-assessments to understand the level of programming and mathematics preparation of the students and post-bridge growth. The programming pre- and post-assessments were based on the curriculum of the first programming course sequence by each partnering school. The bridge programming curriculum included programming lectures and labs with hands-on practical exercises that focused on problem-solving and was taught in Python, Java, or C++.

The mathematics pre/post-assessment focused on algebraic skills and foundational concepts necessary for success in pre-calculus and calculus. Assessment results informed the content and emphasis of subsequent mathematics workshops or courses in which students enrolled, allowing institutions to tailor academic support to student needs.

5.2 Pre- and Post-Student Surveys

Project investigators and the external evaluator collaboratively developed student surveys administered before and after the bridge program to measure changes in students' attitudes, confidence, and sense of belonging toward computing. Survey items were adapted from the Computer Science Attitude Survey and modified to address computing more broadly rather than computer science alone. In addition, belongingness-related items were drawn from the *Attitudes Toward Computing* survey.

Additional questions were included to assess students' perceptions of participation in a broader HBCU learning community and cohort, allowing the evaluation to capture whether students experienced a sense of belonging beyond their individual institutional computing departments. Strongly Agree responses were analyzed separately to highlight the highest level of student confidence and perception change, providing a clearer indicator of meaningful shifts in attitudes. The Computer Science Attitude Survey developed by Wiebe et al. [20] is a 56-item Likert-scale instrument designed for college students, while the Attitudes Toward Computing survey consists of 19 Likert-scale items originally used with high school students. Both instruments have been tested for reliability, and the latter has also been examined for validity.

The surveys were also used to indicate development of STEM identity. For example, measuring confidence in coding and ability reflects competence, belongingness reflects community building, and the "I consider myself a scientist, technologist, engineer, or mathematician" question reflects identity recognition.

Surveys were administered prior to the formation of the intercollegiate HBCU virtual learning community and again at the conclusion of the Summer Bridge Program.

5.3 Observations

The external evaluator conducted structured observations during each day of the one-week, all-campus virtual bridge program to look for program quality of curricula and implementation, alignment with grant goals, successes, and challenges. The evaluator also virtually observed a math and a computing bridge session at one university to get an overall feel for how such programming was being implemented.

5.4 Principal Investigator Focus Group

Following the conclusion of the Summer Bridge Program, project investigators participated in a focus group facilitated by the external evaluator. The focus group provided an opportunity for investigators to reflect on program implementation, progress toward grant objectives, successes, challenges, and areas for improvement.

The qualitative data complemented student assessment and survey results by providing institutional- and implementation-level perspectives.

5.5 Analysis

The evaluator analyzed data collected, comparing means from pre to post survey, comparing means and conducting Wilcoxon signed-rank tests of math and computing pre- and post-test scores, and analyzing qualitative data to identify themes. Data were analyzed at the grant level because that is the level of study; also, analysis by university was not possible because of small N sizes at many of the universities. The evaluator also conducted a preliminary Cronbach's Alpha test on the survey instrument that showed good promise on validity. Among students completing both the pre- and post-bridge 2024 surveys (N=43, 66 percent response rate), half were male and half were female. The largest group (45 percent) was from Hampton University, and the smallest (5 percent) was from Winston-Salem State University.

Participants in the LCI-CS program completed both the pre- and post-10-point computing assessment. For the computing test, a paired sample t-test was conducted to examine the change in participants' computing test scores (maximum 10 points) from pre-intervention (M = 7.33, SD = 1.8) to post-intervention (M = 8.31, SD = 1.7), revealing a significant increase in knowledge, $t(48) = 5.64$, $p < .001$. For the math test, a paired samples t-test was conducted to examine the change in participants' math test scores (maximum 20 points) from pre-intervention (M = 9.82, SD = 3.5) to post-intervention (M = 12.65, SD = 4.4), revealing a significant increase in knowledge, $t(50) = 4.30$, $p < .001$.

6 Results

Results from the Summer Bridge 2024 data indicate promising outcomes related to students' confidence, sense of belonging, and attitudes toward computing. Both quantitative and qualitative data suggest that participation in the LCI-CS Summer Bridge Program supported community formation and early academic confidence among participants.

6.1 Community Formation and Qualitative Findings

Project investigators reported multiple examples of students forming a community, both with each other and with PIs. For example, at one school, some female participants formed a group for women in cybersecurity. Another school saw students form a similar club, with a PI as advisor. At another, students continued to share information with each other through email and texts after summer; the PI was included. Some participants requested to be roommates after the summer program. PIs also observed increased student comfort in seeking guidance and mentorship. One PI noted:

“I think they’re more comfortable just coming to ask me things. I point them in the right direction. So, they do reach out to me a lot.”

These qualitative observations suggest that the learning community model supported relationship building between students and faculty, an important factor in persistence for underrepresented students in computing.

6.2 Changes in Coding Confidence and Attitudes

Survey results showed improved confidence and attitudes about their coding and programming abilities and prospects on almost all items. The following results highlight survey items that demonstrated particularly encouraging trends.

Wilcoxon signed-rank tests showed that the post-survey scores were significantly higher than the pre-survey scores for the following survey items:

- I have a lot of self-confidence when it comes to coding: Mdn for pre = 3.00, Mdn for post = 4.00, $Z = -3.903$, $p = <.001$, $r = 0.595$
- I am sure I could do advanced work in coding: Mdn for pre = 3.00, Mdn for post = 3.00, $Z = -3.903$, $p = <.001$, $r = 0.595$
- I think I could handle difficult coding problems: Mdn for pre = 3.00, Mdn for post = 3.00, $Z = -2.060$, $p = 0.039$, $r = 0.314$
- I feel comfortable coding: Mdn for pre = 3.00, Mdn for post = 4.00, $Z = -2.888$, $p = 0.004$, $r = 0.446$

Not all measures showed gains. As shown in Figure 1, students reported decreased agreement or little change on items related to STEM identity, coding anxiety, and intended major.

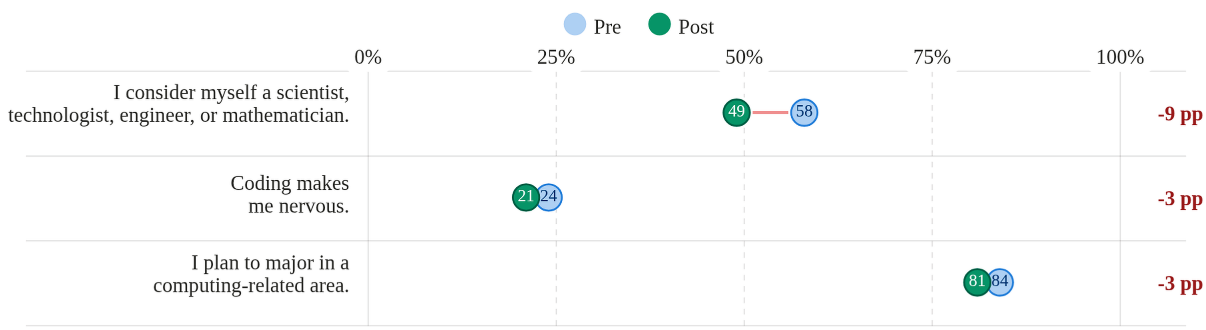

Figure 1: Survey Items Showing Decrease or No Change

Wilcoxon signed-rank tests showed the following differences:

- I consider myself a scientist, technologist, engineer, or mathematician: Mdn for pre = 4.00, Mdn for post = 3.00, $Z = -1.163$, $p = 0.245$, $r = 0.177$
- Coding makes me nervous: Mdn for pre = 4.00, Mdn for post = 3.00, $Z = -0.387$, $p = 0.698$, $r = 0.060$

- I plan to major in a computing related area: Mdn for pre = 5.00, Mdn for post = 5.00, Z = -0.5, p = 0.617, r = 0.076

6.3 Computing and Mathematics Assessment Results

Students demonstrated gains in computing knowledge. Students' mean change in pre- to post-computing scores increased significantly. The mean score on the computing pretest was 7.33 and 8.31 on the post test, an increase of .98 points. As shown in Figure 2, self-reported math confidence showed relatively small changes from pre- to post-survey. However, despite limited changes in perceived math self-efficacy, students demonstrated gains on the mathematics assessment.

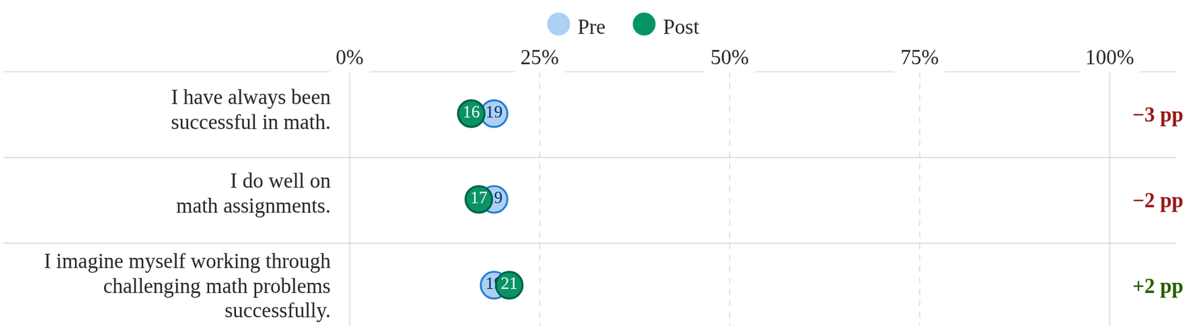

Figure 2: Changes in Strongly Agree Responses for Math Self-Efficacy Items (Definitely True)

Wilcoxon signed-rank tests showed the following differences:

- I have always been successful in math: Mdn for pre = 4.00, Mdn for post = 4.00, Z = -0.586, p = 0.558, r = 0.089
- I do well on math assignments: Mdn for pre = 4.00, Mdn for post = 4.00, Z = -0.051, p = 0.959, r = 0.008
- I imagine myself working through challenging math problems successfully: Mdn for pre = 4.00, Mdn for post = 5.00, Z = -0.768, p = 0.442, r = 0.117

However, students made positive changes on average on the math test. The mean score on the 20-point math pretest was 9.82 and 12.65 on the post test, a significant increase of 2.83 points.

6.4 Sense of Belonging and Academic Skills

Respondents indicated increased feelings of belongingness in the HBCU community on the questions included in the summer bridge pre- and post-survey. Figure 3 presents changes in students' perceptions of belongingness within the broader HBCU computing community.

Responses to study and time management skills related questions did not change much overall from pre- to post-survey. Figure 4 summarizes changes in students' perceptions of their study and time management skills, reporting changes in the percentage of students who selected Strongly Agree.

Wilcoxon signed-rank tests showed the following differences:

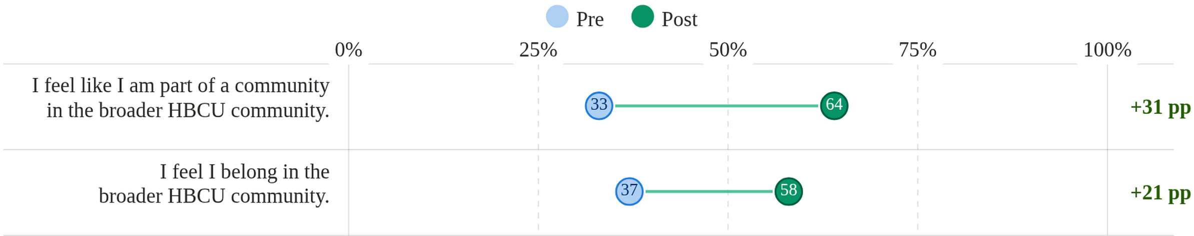

Figure 3: Belongingness in the Broader HBCU Community Survey Items

- I feel like I am part of the community in the broader HBCU community/cohort: Mdn for pre = 4.00, Mdn for post = 5.00, Z = -0.262, p = 0.793, r = 0.669.
- I feel like I belong in the broader HBCU community/cohort: Mdn for pre = 4.00, Mdn for post = 5.00, Z = -0.455 p = 0.649, r = 0.070.

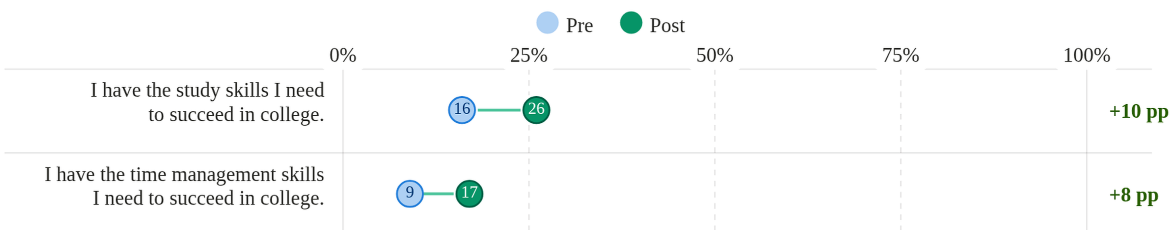

Figure 4: Study and Time Management Skills Survey Items

Wilcoxon signed-rank tests showed the following differences:

- I have the study skills I need to succeed in college: Mdn for pre = 3.00, Mdn for post = 3.00, Z = -1.208, p = 0.227, r = 0.184.
- I have the time management skills I need to succeed in college: Mdn for pre = 3.00, Mdn for post = 3.00, Z = -0.91, p = 0.363, r = 0.140.

Although quantitative changes in these areas were modest, open-ended survey responses provided additional insight. Many students highlighted the value of guest speakers and joint sessions, particularly advice related to time management, study habits, and college success. Students also emphasized the importance of meeting faculty, peers from other institutions, and computing professionals. One student noted:

> "The advice given by the speakers was really helpful. Also, the joint sessions allowed me to cooperate with others while researching something new that I was interested in."

These findings directly address EQ1 and EQ3, demonstrating improvements in students' academic preparedness and sense of belonging within computing-related contexts. Together, the results suggest that the bridge program supports both cognitive and non-cognitive factors associated with early student success.

7 Discussion

Preliminary results from the collaborative summer bridge program suggest that early, community-based interventions can support underrepresented students as they prepare to enter computing-related majors. Students demonstrated gains in confidence, academic preparedness, and sense of belonging; however, these outcomes should be interpreted in the context of the program's design and implementation. In particular, the findings highlight the importance of community-building opportunities, variation in program models across institutions, and sustained, high-touch engagement beyond the summer period.

7.1 Program Model Implementation and Variation

An important aspect of this project was how the bridge program was implemented across participating institutions. Although all campuses participated in the one-week joint virtual sessions, each institution adopted either a course-driven model or a boot-camp–style model for their local bridge programming. These differences reflect variation in institutional structures, student populations, and existing summer programs.

Based on early observations, both models appeared to support gains in student preparedness and confidence. The course-driven model emphasized extended engagement with academic content, while the boot-camp model focused on rapid exposure to campus life, academic expectations, and foundational computing concepts. Rather than indicating a single optimal approach, these findings suggest that multiple implementation models may be effective when aligned with shared learning community goals.

7.2 Promoting Community Building Within and Across Institutions

A central goal of this project was to explore how community-based programs, such as a collaborative summer bridge program, can broaden participation in computing-related majors by fostering connections within and across institutions. Early findings suggest that students more easily formed peer connections within their home institutions, even though inter-institutional connections were initiated during the joint virtual sessions.

These observations indicate that while virtual engagement can support cross-campus community building, additional or sustained opportunities may be needed to strengthen connections among students from different institutions. At the same time, the project demonstrates that belongingness can operate at multiple levels, extending beyond a single department or institution to a broader HBCU computing community.

The data suggest that the summer bridge program was associated with increases in students' sense of belonging, particularly within their own HBCU institutions. While students reported increased belonging within their institutions, smaller changes in STEM identity measures may reflect the short duration of the program. Developing a STEM identity often requires sustained engagement, repeated validation, and longer-term academic experiences. The bridge program may serve as an initial catalyst, but continued exposure during the academic year is likely necessary for deeper identity formation. As the program continues to be implemented with two additional cohorts, we will continue to explore to what extent the program can impact students' sense of belonging and confidence in STEM.

7.3 Importance of High-Touch Programming

An important realization that emerged from this work is the role of high-touch programming in supporting student participation and engagement. Although the bridge program was intentionally designed as a collaborative learning community, variation in student engagement highlighted the need for frequent faculty check-ins, structured group activities, and individualized mentoring.

Across institutions, faculty observed that more consistent and intentional interactions with students were essential for sustaining engagement and building confidence in computing. These insights have prompted ongoing discussions among the project team about how to more intentionally incorporate high-touch strategies into future iterations of the program, particularly as students transition from the summer bridge experience into the academic year.

8 Conclusion and Future Work

This work-in-progress examined the design, implementation, and early outcomes of an intercollegiate, learning community-based summer bridge program aimed at supporting underrepresented students entering computing-related majors at HBCUs. The findings suggest that a collaborative bridge model that combines foundational academic preparation with intentional community-building opportunities can support students' confidence, academic readiness, and sense of belonging as they transition to the academic year.

Across institutions, students demonstrated gains in computing and mathematics preparedness, increased confidence in coding, and increased feelings of belonging within a broader HBCU computing community. Qualitative findings further highlighted the role of peer connections, faculty engagement, and cohort-based experiences in fostering early academic and social integration.

This project contributes to the computer science education literature by providing early evidence on the implementation of an intercollegiate learning community model across multiple HBCUs. The variation in local program models, combined with a shared virtual experience, offers insight into how flexible approaches can be aligned around common goals. Importantly, the findings also point to the value of high-touch engagement strategies, including frequent faculty interaction and structured peer support, as key elements in supporting underrepresented students in computing.

Future work will examine longer-term outcomes, including first-year retention and persistence, as students continue through academic-year lecture series and service-learning activities. In conclusion, this work highlights the potential of collaborative, learning community-based bridge programs to broaden participation in computing.

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