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WIP: The Impact of a Mathematics-Focused Summer Bridge Program on First-Year Engineering Students' Preparation and Retention

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Introduction

The transition from high school to college can be particularly challenging for first-year engineering and computer science students, especially those who may not have had access to rigorous STEM coursework. To address these challenges, many universities have implemented summer bridge programs designed to provide additional support and preparation for incoming students. Summer bridge programs have been widely recognized as effective interventions for improving retention and success rates [1], particularly among underrepresented and underprepared students in STEM fields (e.g., [2], [3], [4]). These programs typically offer a combination of academic instruction, advising, and mentorship, which collectively help students build a strong foundation for their college education (e.g., [2]). Research has shown that participation in summer bridge programs can lead to higher GPAs, increased retention rates, and a greater likelihood of graduating with a STEM degree [5].

Research shows that bridge programs providing targeted academic preparation and mentorship are critical for increasing retention and success rates among students who may not have had equal access to rigorous STEM coursework prior to college (e.g., [6]). Indeed, one of the primary goals of summer bridge programs is to address gaps in foundational academic preparation, particularly in mathematics (e.g., [7]). For engineering and computer science students, proficiency in math is crucial, as it underpins much of the coursework in their degree programs [8]. Studies have demonstrated that students who participate in summer bridge programs with a strong math component are better prepared for university-level calculus and other advanced math courses [5]. In addition to academic preparation, summer bridge programs also play a significant role in fostering a sense of belonging and inclusion among students, which is critical for retention in STEM [9]. Many participants in these programs come from diverse backgrounds and may face unique challenges in their pursuit of a STEM education. By providing a supportive environment that includes mentorship, holistic academic and personal development, and cultural immersion activities, summer bridge programs help students build their support network which can be instrumental in their academic and personal success [2].

Our engineering bridge program at the University of Washington is designed to support talented but underrepresented incoming first-year students pursuing degrees in engineering and computer science. To support these students, our recently redesigned four-week summer bridge program focuses on preparing first-year students for university-level math and easing their transition to a large R1 university. Initiatives at other institutions, such as the Engineering Summer Bridge Program at Penn State [10] and the UVA Engineering Summer Bridge Program at the University of Virginia [11], similarly emphasize math preparedness, academic advising, and mentorship and have demonstrated their effectiveness in closing academic gaps, improving retention, and fostering greater inclusivity in STEM fields. These comparisons highlight the diverse approaches to supporting first-year engineering students and underscore the importance of tailoring

programs to meet the specific needs of their participants. By fostering a sense of belonging and providing comprehensive support, summer bridge programs play a crucial role in promoting inclusion and diversity in engineering education.

Background on Our Program

The Washington State Academic RedShirt (STARS) program at the University of Washington [12] initially launched through an NSF grant twelve years ago. STARS executes a two-year, cohort-based model that provides academic support in prerequisite courses through workshops, tutoring, and skill-building seminars. Our program was inspired by the athletic concept of the "red shirt" year to give first-year students extra preparation for success in engineering and computer science as well as University of Colorado Boulder's GoldShirt program [13]. STARS is unique in its comprehensive approach and interdisciplinary collaboration across the university and broader community. This includes STEM units such as the mathematics and chemistry departments as well as student support services, such as academic advising and career services. Through diverse partnerships and tailored supports, STARS provides students with holistic preparation for the rigor of STEM degrees. We also connect students with staff, faculty, and industry mentors to support students' personal, professional, and leadership skill development. Our model recognizes that success in engineering and computer science extends beyond technical knowledge, encompassing a broader set of skills and resources necessary for academic achievement and personal growth.

The two-year STARS program launches with a summer bridge component prior to the start of the students' first year. We recently redesigned the summer bridge component of our program, launching the redesigned version in the summer of 2024 for the entering cohort. Our summer bridge curriculum enhancements aimed to improve math preparedness and accurate course placement, ultimately contributing to higher retention and success rates. Changes included doubling the length of instruction from two weeks to four, building a new curriculum aimed at preparing for university-level pre-calculus, and implementing weekly assessments to track student understanding. We also improved the placement process by which we place program participants into the appropriate math course in the first term of their first year. Partnerships and interdisciplinary collaborations were also strengthened to better utilize the resources available in other departments on campus outside of engineering. The goal of these improvements was to ensure students enter their first year with a solid foundation in mathematics, better preparing them for the challenges of STEM coursework. By strengthening math preparation and leveraging cross-departmental expertise, we aim to improve students' academic performance and retention in engineering.

Purpose

Summer bridge programs are vital in supporting the transition of first-year engineering and computer science students to college, particularly those who have faced barriers to comprehensive STEM education. This paper evaluates the impact of the summer bridge redesign on student outcomes, presenting the preliminary analysis. We seek to answer the following

research questions: *What impact does the redesigned summer bridge program have on math preparation levels of first-year engineering and computer science students? To what extent does the redesigned curriculum enhance the accuracy of math course placement for incoming students?*

Methods

Our methods include both quantitative and qualitative assessment tools. We collected data through student feedback surveys administered to the first-year engineering and computer science students who participated in the revised summer bridge program. The data was collected at the end of the fall term 2024, after students completed their first math course, so that students were able to effectively reflect on the impact of the bridge program and the accuracy of their placement in the appropriate math course during the fall 2024 term. The surveys sought to elicit insights into students' experiences, perceptions of readiness and accurate course placement, and areas for improvement of the bridge program, asking students to reflect on how they felt before the bridge program, after the bridge program but before the fall term, and after the fall term. The surveys include Likert-style questions to quantify student confidence and preparedness in key areas such as math, as well as open-ended questions to gather qualitative feedback on students' personal experiences and expected challenges for their first year.

Our preliminary data analysis evaluated students' self-reported preparation levels at three different points in time: before the summer bridge program, after the summer bridge program but before the fall term, and at the end of the fall term. We also compared the students' self-reported preparation levels with their actual academic performance in their fall math course (i.e., their final grades). To provide context to the quantitative survey responses, we qualitatively analyzed the open-response questions to identify similarities amongst the students, particularly with regards to the challenges they face. These analyses will help us gauge the impact of the program, particularly students' long-term academic performance in core math courses, persistence in major selection, and their sense of belonging within the engineering and computer science communities.

Results

Of the 41 students in our cohort this academic year 2024-2025, 3 were placed in the calculus 1 course at the end of the summer bridge program, 27 were placed in the precalculus course, and 11 were placed in the introduction to elementary functions course. The survey at the end of the fall term was sent to all 41 students, and we received 16 responses, corresponding to a 39% response rate. Overall, our preliminary results from the first year of the modified curriculum reveal positive trends in student satisfaction, confidence, and engagement with the math course in the fall term. The respondents indicated feeling well-prepared for the math courses in the fall term, but that time management and workload remained as challenges.

When asked on the survey whether students felt prepared for university-level math *prior to the summer bridge program*, 50% disagreed or strongly disagreed while only 25% agreed or strongly agreed (Figure 1), indicating that the majority were concerned about the transition to college. Students further elaborated in the open response questions, citing concerns around the difficulty and pace of the courses, managing the workload, and their prior knowledge, including a lack of recall and insufficient preparation from previous courses. They also worried about their ability to understand new concepts. Interestingly, while all students voiced concerns, only one expressed a "positive" challenge, fearing that they would not be sufficiently challenged in the math course.

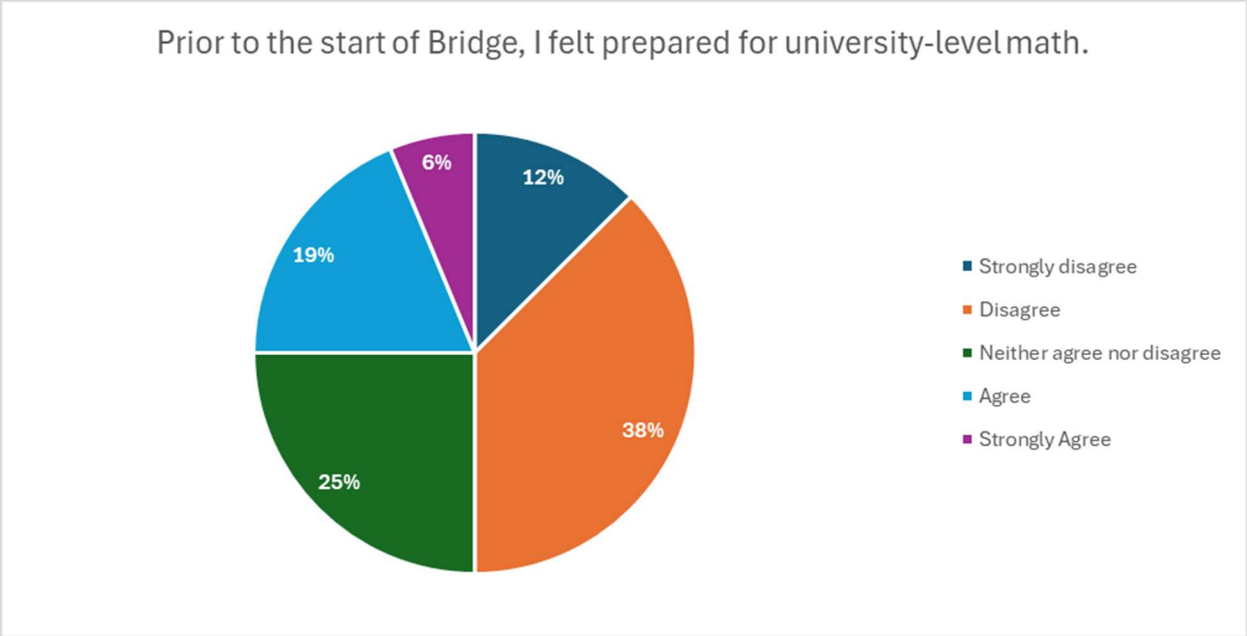

Figure 1: Survey responses to "Prior to the start of Bridge, I felt prepared for university-level math."

When students were asked whether they felt prepared for university-level math *after attending the summer bridge program but before taking their fall math courses*, there was a remarkable difference to their pre-bridge preparation levels: 57% indicated they agreed or strongly agreed that they felt prepared, with only 12% disagreeing (Figure 2). For individual students, 10 of the 16 indicated increased confidence in their preparation, while 4 did not indicate a change and 2 felt less confident. Providing context to these numbers, students further reported a decrease in perceived difficulty, describing math as 'moderate,' 'manageable,' or 'somewhat hard.' However, specific challenges like word problems and time management remained, along with cognitive and learning-specific issues such as focus, recall, and retaining information. Overall, many students viewed the bridge program as good preparation or refresher. These differences before and after the bridge program indicate the impact that the summer bridge program had on increasing students' mathematics confidence prior to starting their first math course.

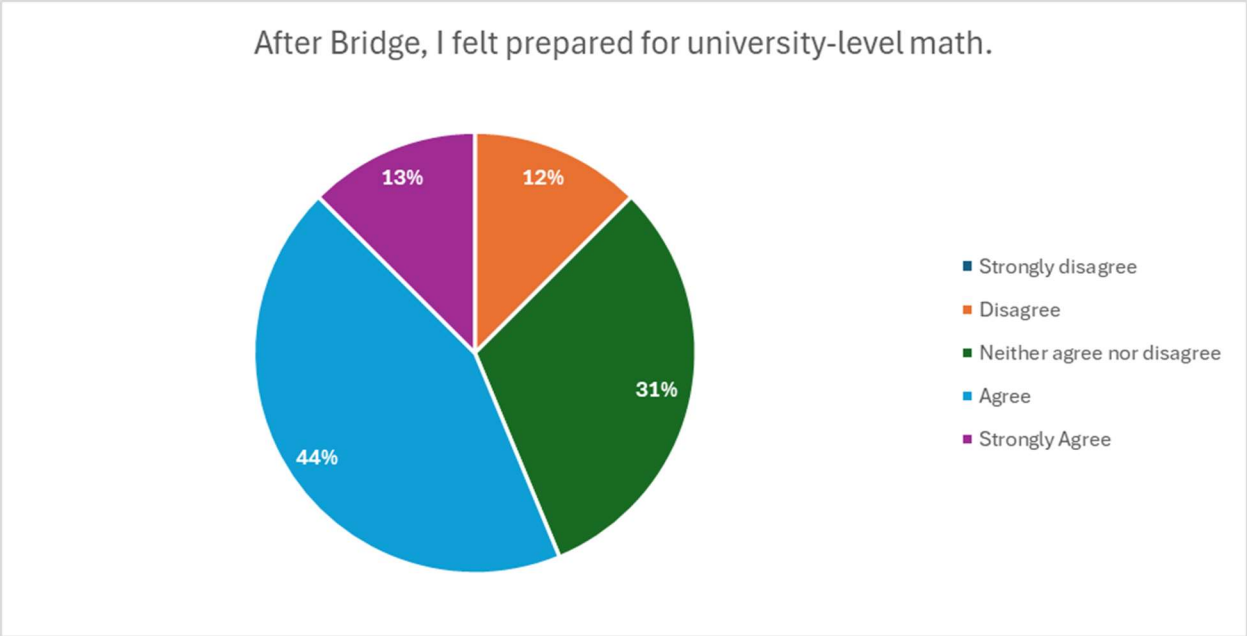

Figure 2: Survey responses to "After Bridge, I felt prepared for university-level math."

Upon completing their fall term, students were asked whether the summer bridge program helped in their fall math course. We found that there was an overwhelming agreement that the summer bridge program positively impacted their performance in their math course: 38% strongly agreed, 50% agreed, and 12% indicated neither agree nor disagree. Upon further elaboration, most students felt they were doing well and were prepared, though two still reported poor performance or a lack of understanding. Workload and time management continued to be dominant issues, along with adjusting to college life, creating study habits and routines, and dealing with a lack of effort and motivation. Additionally, when asking students whether they thought they were accurately placed in their math course, of the 16 survey respondents, 6 strongly agreed that their math placement was accurate, 6 agreed, 2 neither agreed nor disagreed, and 2 did not agree with their math class placement. The students that disagreed with the placement were both placed in the precalculus course, where the majority of the program participants were placed.

We also compared the students' self-reported preparation levels to their actual performance in their fall term math courses, finding that 80% of the students in the cohort achieved a final grade of an A or B in their math course (Table 1). Across the cohort, only 1 student dropped their course (they were placed in the calculus I course), and only 3 students did not pass their class (2 in precalculus and 1 in elementary functions). Of the three placed in the highest math course, calculus 1, one student dropped while the other 2 achieved a final grade of A. For the course with the greatest number of placements, precalculus, 24 of the 27 achieved an A or B final grade. Such high academic achievement by the students in their first university-level course makes us optimistic that our improved placement process more accurately placed students in the math course that best fits their needs.

Table 1: Student Academic Performance in their Fall Math Course

Course	A	B	C	D	Failure/Not Satisfactory	Dropped Course	Total
Intro to Elementary Functions	6	1	1	2	1	0	**11**
Precalculus	19	5	1	0	2	0	**27**
Calculus 1	2	0	0	0	0	1	**3**
Total	**27**	**6**	**2**	**2**	**3**	**1**	**41**

Overall, our preliminary results indicate that the revised summer bridge program increased student confidence in their preparation for university-level math and that they were accurately placed in the correct math course for the fall term, as evidenced by both their survey responses and their high academic performance in their respective courses.

Next Steps

The preliminary results of our redesigned summer bridge program show improvements in proper math placement and student confidence entering their first year of an engineering or computer science program. We are continuing to track student progress throughout their first year to evaluate the long-term impact of the program, particularly the accuracy of our process in placing students in the correct math classes during their first year and whether accurate placement leads to greater retention in engineering and computer science majors. We plan to interview students based on their responses, particularly those who felt that their placement was incorrect, to understand why students felt that it was incorrect so that we can continue to improve our placement process and its accuracy. We are also interested in students' math confidence levels throughout their first year, as well as their overall experience with a sense of belonging and their plans to continue pursuing an engineering or computer science degree. Further, we plan to track how their performance in their math courses changes as they progress through the calculus sequence so that we may modify the math preparation given during the summer bridge program to better support their continued academic performance. Our future analysis will provide further insights into future curriculum modifications, such as exploring essential problem-solving and teamwork skills, as these are critical factors for long-term success in STEM fields.

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