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WIP: Introducing Research in Summer Bridge Programs

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Introduction

A challenging issue for most engineering degree programs is the relatively high rate (~50%) that undergraduate students leave or switch from engineering majors before graduating [1], [2], [3], [4]. Previous work shows that a significant portion of STEM students (~35%) switch majors or leave the university between the first and second year in their degree [2], [5], [6]. These attrition numbers are even higher for students from historically underrepresented groups [7], [8]. As a result, it is most helpful to implement intervention strategies that help engineering students persist beyond their second year.

One proven method to increase retention and graduation rates of historically underrepresented engineering students is inclusion within a summer bridge program [9], [10], [11], [12]. In general, a summer bridge program is designed to facilitate the academic and social integration of incoming undergraduate students to a new learning environment as they transition from high school to college. They are typically structured to expose students to abbreviated versions of core engineering curriculum courses (e.g., calculus, chemistry, physics, etc.), while building community within their cohort and illuminating success strategies and resources. Many bridge programs are designed and evaluated based on short-term goals such as social integration and long-term goals such as increased retention in the discipline and graduation rates. The outcomes from these programs vary depending on factors such as type of goal (academic, psychological, and departmental) and comparison group [13].

Another intervention that has shown a positive impact on student retention is undergraduate research experiences [14], [15], [16], [17]. This intervention has also been particularly effective for students from traditionally marginalized communities [18], [19], [20]. However, the literature also points to several barriers that hinder undergraduate student participation in research, including awareness of the extent of research opportunities available, how to connect with faculty and/or navigate the application process, and not understanding the potential benefits including financial compensation [21], [22], [23]. There are several programs and university offices dedicated to expose students to research opportunities and support their involvement in these experiences [24]. Most notably, the Meyerhoff Scholars Program at the University of Maryland Baltimore County prepares undergraduate students for graduate school through research opportunities, mentoring, and community building programs [25]. This program alone has produced hundreds of students who chose to pursue advanced degrees in a STEM graduate program [25], [26].

While undergraduate research is an effective intervention and prepares students for a range of future opportunities (not just graduate school), many students do not pursue research opportunities until their junior or senior years. As a result, its impact on the critical retention window between a student's first and second years is diminished. Therefore, we propose exposing undergraduate students to research skills and opportunities as early as possible in their college journey. In this paper, we describe the design and implementation of a combined intervention model, where we leveraged an existing 6-week summer bridge program by adding an introduction to research course to the curriculum. To assess the impact of this enhanced bridge program, we used pre- and post-program surveys to measure any change in student attitudes towards self-efficacy and sense of belonging, as well as their likelihood of pursuing an undergraduate research opportunity and graduate school. We also examined the preliminary effect of the combined intervention model on first semester GPAs, retention rates and engagement with research experiences. Initial results indicate that enhancing a summer bridge program with an introductory research course can significantly increase student interest in research, which has the potential to also increase the likelihood they will engage in an undergraduate research experience and gain the associated benefits.

Project Approach and Assessment Methods

Our project approach included adding an introduction to research course to an existing summer bridge program curriculum through scheduled bi-weekly classes that all students were required to attend. We then evaluated the effectiveness of this combined intervention model on student attitudes towards research, self-efficacy, and belonging as well as academic success metrics.

Summer Bridge Program Description

Our summer bridge program is a 6-week, residential program, designed to support incoming first-year students entering their engineering discipline through both academic enhancement and community engagement events. The program is open to all students, with an emphasis on historically underrepresented students. The student cohort for this paper consists of 28 students, including those attending as required by their scholarship program, as well as those who self-selected to participate. Participants are exposed to subjects such as pre-calculus/calculus, chemistry, and metacognition. They learn how to prepare for the rigor of the curriculum through exploring various study skills and through active participation in daily group review sessions. Participants also learn critical team building skills through engaging in a 6-week robotics competition and gain valuable professional development through weekly enrichment sessions. Each of these program components are fortified by rising second year student mentors, having participated in the program the previous year. The mentors are trained and empowered to support program goals, develop activities, and respond to participant weekly reflections [27].

Introduction to Research Course Description

The “Intro to Research” course focused on increasing student awareness of research concepts and opportunities. The primary learning objectives of the research course included: 1) understanding the benefits of trying research as an undergraduate student; 2) thinking like a researcher; 3) connecting engineering interests to active research projects; 4) practicing research skills such as problem-solving, communication and teamwork; and 5) building relationships with university students, faculty and staff who can help identify research opportunities. To achieve these goals, all summer bridge students attended a research class that met two times per week with a dedicated professor. The class structure consisted of hands-on learning modules and excursions to state-of-the-art laboratory facilities on campus.

We collaborated with two graduate students to integrate a current research project about sustainable cement into the curriculum that allowed for bridge program student participation. The project served as the foundation for introducing several research concepts and provided a way for students to see research progress from creating cement samples with different sustainable materials (e.g., agriculture waste products, blast furnace slag or sand) to testing their compressive strength by the end of the summer. The sustainable cement theme was also incorporated in other classroom activities including providing the topic for learning about community-based participatory research.

Classroom activities also emphasized inquiry-based learning methods that address open-ended problems in research to enhance student success by increasing their tolerance with uncertainty. For example, students collaborated on mini projects that involved hypothesis testing and experimental design/optimization. To elevate the learning with all course activities, students were given an official laboratory notebook to organize their notes and collect data. Students were asked to write the answer to the following questions in their laboratory notebooks following every research encounter:

- Why should anyone care about this research? Why is it important?
- What are the researchers trying to do? What methods are they using to solve the research problem? What is new and exciting about this approach?
- Does this kind of research spark my interest? Why or why not?

To ensure students finished the program with the wherewithal to find undergraduate research opportunities, an entire class was dedicated to the process of identifying both internal and external research experiences. In addition, students were connected to several people in the College of Engineering who could provide guidance about the research process including the Director of Student Research as well as several graduate students and undergraduate students currently engaged in positive research experiences.

A key component of our pilot course was the involvement of seven student mentors who highlighted pathways for engagement in research, participated in guided discussions of the opportunities and benefits of research involvement, and provided student perspectives of benefits. Student mentors also helped integrate research methods and mindset with a robotics competition that all summer bridge students participated in.

Program Assessment

We hypothesized that our pilot Intro to Research course will increase interest and self-efficacy in research activities, thereby enhancing the probability that students will participate in voluntary research experiences, and as a result enhance student retention and graduation rates. Pre- and post-program surveys were designed to determine the short-term impacts of the research class and summer bridge program on student attitudes regarding research, self-efficacy and sense of belonging at the university. The surveys included statements on a 5-point Likert scale that allowed students to express how well the statement describes them ranging from “describes me extremely well” to “does not describe me.” In addition, students evaluated the pilot research course itself at the end of the summer bridge program.

Longer-term impacts of the research class and summer bridge program can be measured through analysis of cumulative GPAs, retention in the College of Engineering, undergraduate research experiences, and time to graduation. Although it is early in their academic tenure, we collected this information at the end of the first semester for each participant to note any initial insights.

A total of 20 of the 28 students who participated in the engineering summer bridge program were eligible and consented to participate in the IRB-approved research project (STUDY00025168). Due to the smaller sample size and collection of ordinal data, we used the Wilcoxon signed-rank test to analyze paired pre- and post-survey data.

Results

Overall, the combined intervention pilot program showed an immediate positive impact on student attitudes and first semester achievement. A summary of the pre- and post-program survey results is provided in Table 1 for the student attitudes toward research and in the Appendix (Tables A1 and A2) for student attitudes toward self-efficacy and belonging. As shown by the pre- and post-program means in these tables, there was a positive shift in attitudes towards research, self-efficacy and belonging for all statements in the survey.

The primary objective of the project was to determine the impact of an introduction to research course on student attitudes toward research and increase the likelihood of their engagement in a research experience. Most students entered the summer bridge program with an interest in trying research as an undergraduate student. Despite this initial strong interest, students indicated a significantly higher interest in research by the end of the summer bridge program ($p < 0.01$). However, over the course of the program, there was not a significant change in student confidence in being able to find research opportunities ($p = 0.097$) or their interest in pursuing an advanced degree in graduate school ($p = 0.2091$).

Table 1. Comparison of pre- and post-survey responses for attitudes toward research.

Survey Question[a]	Pre-Survey Results				Post-Survey Results				p-value[b]
	Mean	SD	Med	Mode	Mean	SD	Med	Mode	
I am interested in finding a research opportunity as an undergraduate student.	3.85	0.93	4	3	4.60	0.60	5	5	0.002027**
I believe I can find research opportunities.	4.15	0.75	4	4	4.55	0.69	5	5	0.097
I am considering graduate school to get a Master's degree or Ph.D.	3.00	1.34	3	4	3.30	1.34	3	3	0.2091

[a]5 = describes me extremely well; 4 = describes me very well; 3 = describes me moderately well; 2 = describes me slightly well; 1 = does not describe me
[b]Significance level determined with Wilcoxon Signed Rank Test ($p<0.05$)*, ($p<0.01$)**

We also followed up with the students regarding their interest in research at the end of their first fall semester at the university. As shown in Figures 1 - 3, we duplicated the three pre- and post-program survey questions about research and found that student attitudes toward research and graduate school had returned to pre-survey levels. In fact, there was a significant drop in interest in research ($p < 0.05$) and confidence in ability to find research opportunities ($p < 0.05$) when compared to the peak values at the end of the summer bridge program. Despite this waning interest, participants reported taking steps to find research opportunities. Of the 20 participants, 15 indicated that they have "applied to or are planning to apply to a research experience" for the Spring 2025 and/or Summer 2025 semesters. In addition, three students have already successfully secured a research position for this academic year.

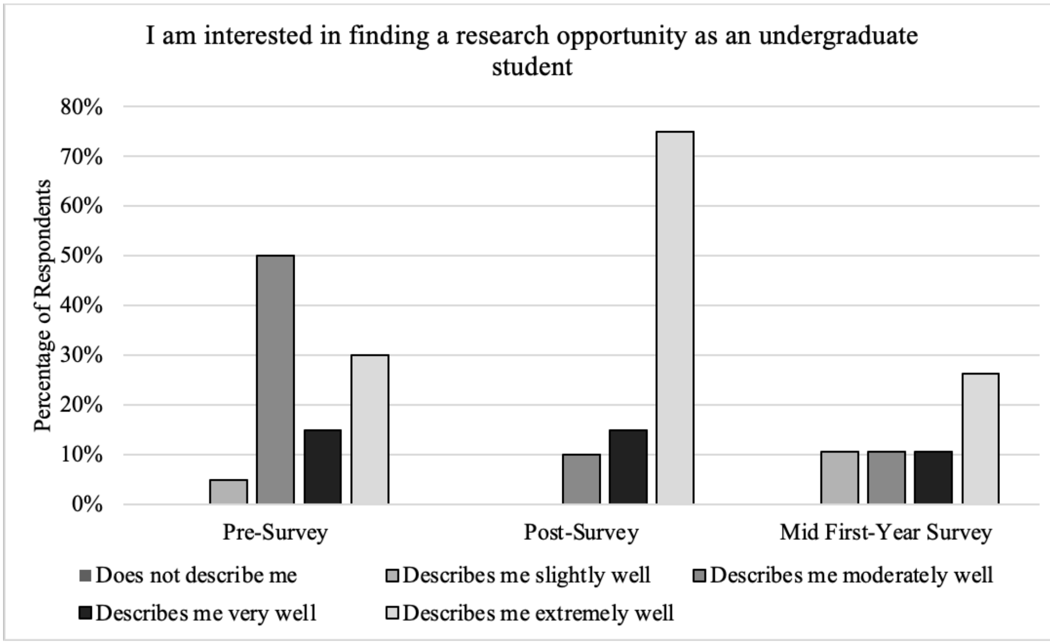

Figure 1. Change in student attitudes over time (before the start of the program, at the end of the program and after first fall semester) about interest in trying research.

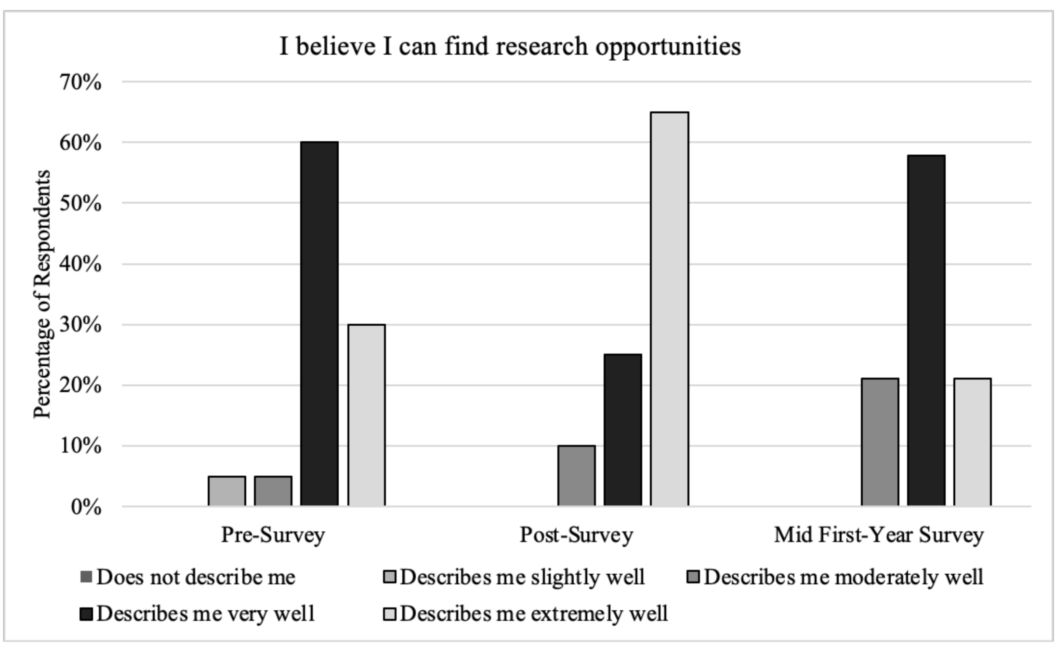

Figure 2. Change in student attitudes over time (before the start of the program, at the end of the program and after first fall semester) about ability to find research opportunities.

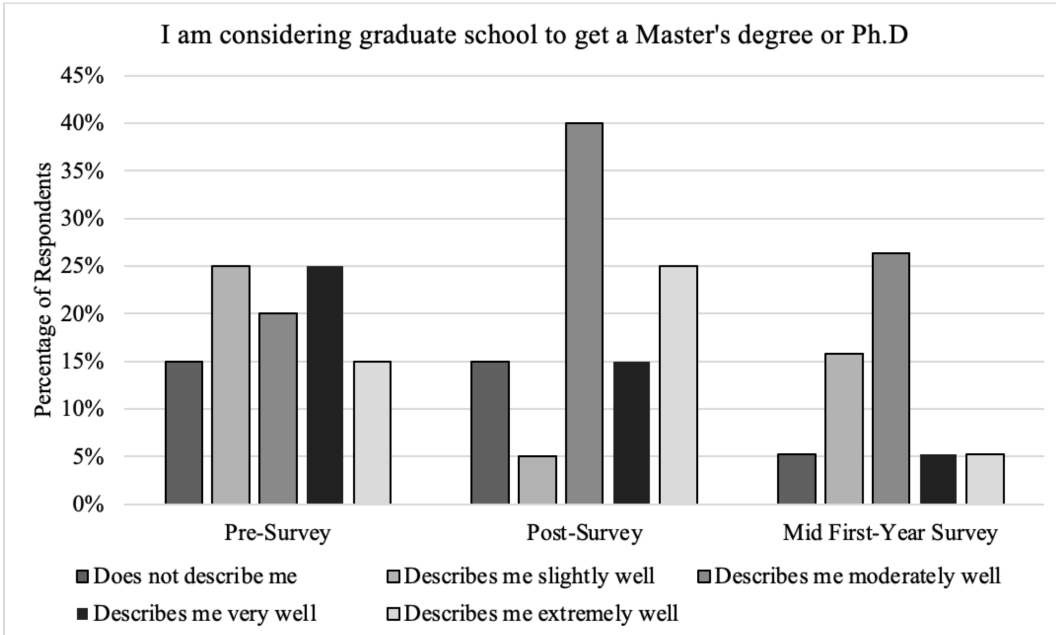

Figure 3. Change in student attitudes over time (before the start of the program, at the end of the program and after first fall semester) about interest in attending graduate school.

Additional survey data was collected regarding participant attitudes toward self-efficacy and sense of belonging at the university and are shown in Tables A1 and A2 of the Appendix. Most students entered the summer bridge program strongly motivated to work hard in their STEM program and that did not change over the course of the program. By the end of the program, students clearly felt more prepared to complete the academic requirements ($p < 0.01$) and navigate the social dynamics ($p < 0.01$) of a STEM program. Similarly, the summer bridge program also had a positive effect on student beliefs that they possess the social skills to navigate the rigors of a STEM major ($p < 0.05$).

Pre- and post-surveys included 7 questions about community and belonging. The questions that saw the largest shift in median results were whether absence of a student from class would be missed ($p < 0.001$), as well as their sense of belonging as a STEM major ($p < 0.01$) and support from their classroom community ($p < 0.01$). Students feeling connected with faculty, staff, and peers as well as their belief that others rely on them for support also saw a significant increase ($p < 0.05$) from the beginning to the end of the program. Most participants entered the program feeling either “extremely well” or “very well” about working with people from different backgrounds, so there was not a noticeable difference between the pre- and post-survey results.

Finally, we collected a few student success metrics for the project participants including retention and cumulative GPA data. All 20 project participants are still enrolled at the university with plans to major in engineering. Figure 4 shows the distribution of the fall semester cumulative GPAs for the project participants. The average cumulative GPA for this cohort of students at the end of the fall semester was an impressive 3.33 (+/- 0.69) with 13 students achieving a cumulative GPA > 3.47. This GPA average is quite a bit higher than the average cumulative GPA for the previous year cohort (2.77 +/- 0.83) at the end of their first fall semester.

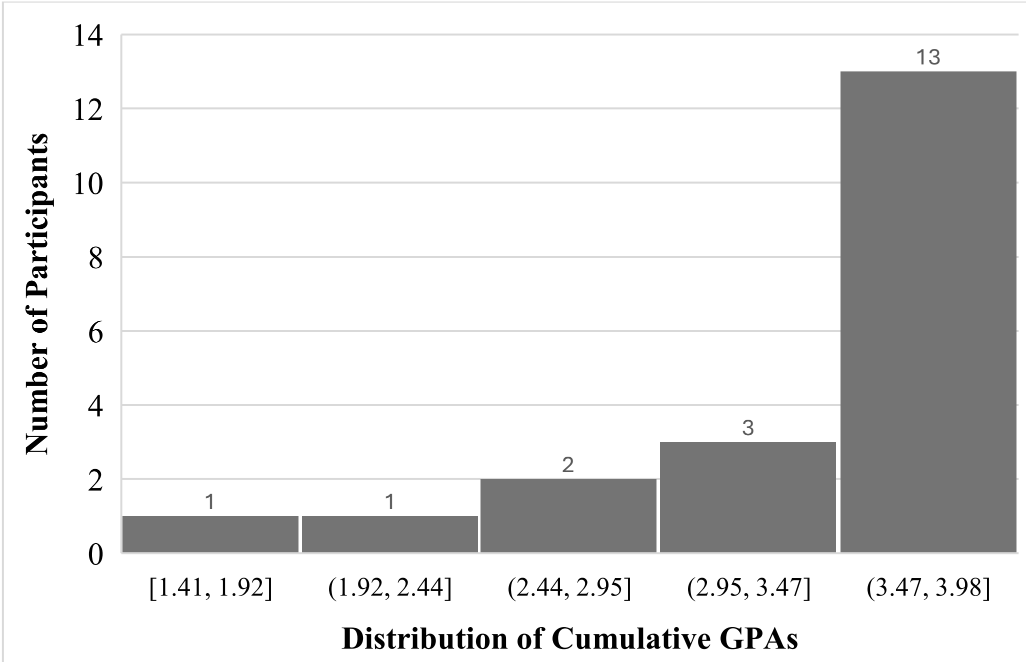

Figure 4. Distribution of cumulative GPAs for summer bridge participants after their first fall semester.

Discussion

While it is too early to know the long-term impacts of adding a research course to a summer bridge program on engineering student retention and graduation rate data, the initial data show some promising results. Although many of the students entered the summer bridge program with a high interest in research, there was still a statistically significant increase in the expressed likelihood of trying research. This increase in interest translated to a majority of the study participants actively searching for research positions during their first year in college. Interestingly, the mid-year survey of research interest significantly decreased from its peak at the end of the summer bridge program. This result indicates the importance of following up with students post-summer bridge program to keep the idea of trying research in the forefront when there are competing co-curricular opportunities (e.g., student organizations, internships, etc.). Example follow up activities include dedicating multiple Multicultural Engineering Program events to undergraduate research, reconnecting bridge students to research groups they interacted with during the summer, etc.

The pilot version of the research course successfully accomplished several of the learning objectives as well as provided lessons learned for future iterations. According to the end of program evaluation, the research course was generally well-received by the summer bridge participants. On a scale of 1 to 10, the students rated the course an average of 8.85 (+/- 1.23). Furthermore, on a scale of 1 to 5, the students rated the "overall importance of the knowledge learned in the course" as 4.95 (+/- 0.22). Specific student survey feedback indicated the following "worked well" for learning about research: guest speakers, activities outside of the classroom, introduction to graduate students and undergraduate students currently doing research, and use of a laboratory notebook throughout the class. Suggested changes to improve learning about research included: exploring a wider variety of engineering disciplines through research, expanding activities to include writing about research, incorporating even more hands-on activities, and scheduling the class for more than an hour twice per week. The research course was not successful at increasing student interest in graduate school, which should also be considered with any modifications to the course syllabus.

An unexpected outcome of the pilot introduction to research course was the many benefits of employing student mentors. Incorporating student mentors in the research course was an effective way to inject enthusiasm for the research activities and appears to have positively impacted their own interest in pursuing research while undergraduate students. Based on mid-year feedback following the summer bridge program, 2 of the 7 student mentors are pursuing research opportunities this spring and 2 are actively seeking research opportunities for this upcoming summer. In addition, program staff and faculty have met with 4 of the student mentors to discuss their plans to apply to graduate school. A potential opportunity to continue this impact is by inviting the summer bridge participants (especially those who try research in the next year) to serve as student mentors next summer.

Next steps for data analysis include further examination of weekly student video reflections. Prompts included inquiries associated with 1) navigating challenges, 2) learning strategies, 3) habit formation, 3) relationship building, 4) resources, 5) inspiration, 6) goals, and 7) program evaluation. These videos along with qualitative responses to survey questions contain rich information which would benefit from thorough analysis. Once we code this data, we can compare findings to quantitative data collected through surveys. Additionally, in the next iteration, we plan to add a question to weekly reflection prompts pertaining to research and the participants' experience within the introduction to research course.

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Appendix A. Pre- and Post-Program Survey Results

Table A1. Comparison of pre- and post-program survey responses for attitudes toward self-efficacy.

	Pre-Survey Results				**Post-Survey Results**				
Survey Question[a]	Mean	SD	Med	Mode	Mean	SD	Med	Mode	**p-value**[b]
I believe I have the academic skills needed to navigate the rigors of a STEM major.	3.90	0.55	4	4	4.15	0.67	4	4	0.1521
I believe I have the social skills needed to navigate the rigors of a STEM major.	3.75	1.02	4	4	4.15	0.81	4	5	0.0367*
I believe I am strongly motivated to commit the effort needed to be successful in a STEM program.	4.45	0.69	5	5	4.60	0.60	5	5	0.1006
I believe I have the ability to recover/learn from setbacks, mistakes or failures I will make within a STEM program.	4.20	0.83	4	4	4.55	0.69	5	5	0.09534
I believe that I am currently prepared to complete the academic requirements (Calculus, Physics, Chemistry, etc.) for a STEM major.	3.45	1.15	3.5	3	4.15	0.81	4	4	0.0067**
I believe that I am currently prepared to navigate the social dynamics within a STEM program.	3.80	0.77	4	4	4.35	0.81	4.5	5	0.0085**
I believe I am open to changing my learning strategies based on feedback from others (professors, facilitators, peers), assessments (homework, quizzes, tests), and/or other unforeseen factors.	4.40	0.82	5	5	4.60	0.50	5	5	0.3521
I believe I work well in collaborative settings or small groups.	4.45	0.69	5	5	4.35	0.75	4.5	5	0.6267
I can tolerate uncertainty when solving complex problems.	3.60	0.60	4	4	3.95	1.10	4	4	0.1307

[a]5 = describes me extremely well; 4 = describes me very well; 3 = describes me moderately well; 2 = describes me slightly well; 1 = does not describe me

[b]Significance level determined with Wilcoxon Signed Rank Test ($p<0.05$)*, ($p<0.01$)**

Table A2. Comparison of pre- and post-survey responses for attitudes toward belonging and community.

Survey Question[a]	Pre-Survey Results				Post-Survey Results				p-value[b]
	Mean	SD	Med	Mode	Mean	SD	Med	Mode	
I identify with and feel a sense of belonging as a STEM major.	3.85	0.93	4	3	4.60	0.60	5	5	0.003591**
I feel connected with faculty, staff, peers, and other community members.	3.80	1.24	4	5	4.50	0.61	5	5	0.01258*
If I were to be absent from a class, I believe others would notice and miss my presence and contributions.	3.10	1.12	3	4	4.20	0.89	4	5	0.000095**
I believe that others rely on me for support.	3.25	1.02	3.5	4	3.70	1.03	3.5	3	0.01466*
I believe that my classroom community cares about my well-being and is invested in my success.	3.80	0.62	4	4	4.35	0.67	4	5	0.005155**
It is easy for me to establish new connections and friendships.	4.00	0.86	4	4	4.05	1.05	4	5	0.85
I am comfortable interacting with others who have different perspectives and/or backgrounds.	4.55	0.60	5	5	4.50	0.69	5	5	0.8016

[a]5 = describes me extremely well; 4 = describes me very well; 3 = describes me moderately well; 2 = describes me slightly well; 1 = does not describe me

[b]Significance level determined with Wilcoxon Signed Rank Test ($p<0.05$)*, ($p<0.01$)**