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Georgia State University Perimeter College LSAMP Transfer Bridge Program: A Path Forward for Broadening Participation in Stem

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Summer Bridge Programs are increasingly becoming a popular strategy for Colleges and Universities to retain more historically underrepresented minority students in Science, Technology, Engineering, and Mathematics (STEM) disciplines. Retaining students in STEM disciplines is a necessary first step in order to accomplish the ultimate goal of diversifying the STEM workforce to create innovative solutions for today's complex problems. In this paper, the authors describe an exploratory and descriptive study of the promising Georgia State University Perimeter College (GSU-PC) Louis Stokes Alliance for Minority Participation (LSAMP) Transfer Bridge Program. Most summer bridge programs are designed to facilitate seamless entry into college for incoming first year students, but the GSU-PC LSAMP Transfer Bridge program is designed to support the successful transition of underrepresented STEM students transferring from a 2-year to 4-year institution. Early results indicate that the Transfer Bridge participants were significantly more likely to enroll in a 4-year STEM program, receive a STEM bachelor's degree, enroll in a post-baccalaureate STEM program, and receive a STEM post-baccalaureate degree than a comparison group of non-Transfer Bridge students at Georgia State University Perimeter College.

Keywords: stem, summer bridge, transfer bridge, diversity, 2-year college, community college, retention

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INTRODUCTION

The growing challenge for the United States to lead in science and technology innovation is a driving force for increasing Diversity in Science, Technology, Engineering, and Math (STEM) disciplines (NRC, 2007; NRC, 2011). The projected job demand in these disciplines enormously outpaces the increases in diversity in STEM disciplines (Mason, 2016). Hence all higher education institutions must address this issue, and 2-year institutions and community colleges are key contributors. In fact, 2-year institutions and community colleges have a long history of playing a significant role in broadening participation for populations historically underrepresented in the STEM workforce including African Americans/Black, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders. There are a number of publications highlighting the accessibility, affordability, and flexibility of 2-year institutions for underrepresented groups, first-generation, low-income, and non-traditional students to enter STEM disciplines and majors (Cohen, Brawer, and Kisker, 2014). Also, there are a number of publications emphasizing the critical role of

community colleges and 2-year institutions in strengthening and expanding the STEM pipeline because of their diverse student populations (NRC, 2012).

Retaining students in the STEM disciplines is vital in diversifying the STEM workforce, and student engagement in summer bridge programs, faculty-mentored research, peer mentoring, group-study, professional development, and research/professional conferences are some high impact activities that correlate with successful student outcomes in STEM disciplines (Maton et al., 2012). These student engagement activities along with other student-focused strategies and approaches are hallmarks in the Louis Stokes Alliance for Minority Participation (LSAMP) Model Elements: STEM Academic Integration, STEM Social Integration, and STEM Professionalization (Clewell et al., 2006). The LSAMP Model integrates the Tinto Model of student retention (academic and social integration) (Tinto, 1975) by engaging students in STEM discipline activities so that they become familiar with their field of study or "Disciplinary Socialization" [a term coined by Bowman and Stage (2002) describing the STEM professionalization element of the model]. The LSAMP program has been successful in significantly increasing the quantity and quality of underrepresented students completing STEM degrees and pursuing graduate degrees in STEM disciplines (Clewell et al., 2006).

Summer bridge programs are one student retention and success strategy that can be designed to employ all three elements of the LSAMP Model. Increasingly, the STEM higher education community are implementing "Bridge" programs to address attrition, Increase graduation, and Encourage graduate education in STEM disciplines (Ashley et al., 2017). According to Michael Ashley et al. (2017), the majority (93%) of STEM bridge programs they reviewed targeted incoming first-year students and only 7% (2 of 30 programs) targeted incoming transfer students. They also found that 50% of the STEM bridge programs supported underrepresented minority students in STEM (Ashley et al., 2017). There are standalone STEM summer bridge programs and ones that are embedded in broader STEM intervention strategies and programs. With the latter model, students have continuous academic, social, and professional support after completing the summer bridge program. An example of a published STEM intervention that embeds a summer bridge program within their model is the University of Maryland Baltimore County's Meyerhoff Scholars Program. Their bridge program targets incoming first year students (Hrabowski and Maton, 1995; Summers and Hraboswski, 2006; Maton et al., 2012).

In this article, we describe the program and research study for the Transfer Summer Bridge Program (Transfer Bridge) that has been implemented at Georgia State University Perimeter College (GSU-PC) since 2009. GSU-PC is the only 2-year partner institution in the Peach State LSAMP and is the major provider of associate degrees and student-transfer opportunities in Georgia. It is a gateway to higher education, easing students' entry into 4-year colleges with an Online College and five campuses in the metro-Atlanta area. The Transfer Bridge is a specialized summer bridge program designed to create successful 2- to 4-year transitions for transfer students majoring in STEM disciplines. Most summer bridge programs are designed to facilitate seamless entry into college, but the GSU-PC LSAMP Transfer Bridge program prepares their STEM students for a seamless transfer from 2-year institutions and successful completion of a bachelor's degree at a 4-year institution. Students participate in the Transfer Bridge after they have enrolled at GSU-PC for at least one semester, as opposed to immediately after finishing high school prior to first-time enrollment as a college student. The Transfer Bridge program demonstrates the importance and effective practices of transfer partnerships. There is a growing consensus that student success is more likely when the 2-year institution actively supports the student and the transfer process and the receiving 4-year institution actively takes responsibility for the student's academic success after the transfer (Finks and Jenkins, 2017).

MATERIALS AND METHODS

GSU-PC Transfer Bridge Program Methods

Georgia State University Perimeter College hosts a rigorous Transfer Bridge program each year in the month of May under the leadership of Professor Margaret Major. The program is a 3 week student-focused, faculty-mentored research training and engagement program. The Transfer Bridge program was designed for GSU-PC LSAMP scholars who have been enrolled at the commuter college full-time for at least one semester prior to the Transfer Bridge program. The primary goals of the Transfer Bridge project are to increase the number of Peach State LSAMP scholars transferring to 4-year Peach State Alliance (and other) colleges and universities and to increase the likelihood they will persist and graduate with a baccalaureate degree in a STEM discipline. The intensive 3-week program not only equips students with comprehensive research techniques and skills used to solve scientific problems, but also introduces them to STEM in industry, cutting-edge research conducted at research institutions, life at a 4-year college as a STEM student, as well as step-by-step processes for transfer admission requirements and acquiring financial aid.

The Transfer Bridge Program supports all three elements of the LSAMP model—STEM academic integration, STEM social integration, and STEM professionalization. Its core high impact activities include mentorship, research training and engagement, partner-facilitated visits to 4-year institutions, and STEM industry tours. See **Table 1** below.

Mentorship

Faculty- and peer-mentoring are key strategies in promoting student academic (both undergraduate and graduate) and career success in STEM disciplines (Hill et al., 2010; NRC, 2011). Research has shown that quality time with a mentor significantly impacts student success for STEM students engaged in undergraduate research (Pita et al., 2013). GSU-PC Transfer Bridge includes formal mentor-mentee and mentoring networks for its participating LSAMP students. The Transfer

TABLE 1 | Transfer bridge high impact student engagement.

Transfer bridge student engagement activities	
Mentorship	Small groups of students participate in a learning community lead by a faculty member
Research experience	Students work directly with faculty members on a "mini" research project for 3 weeks and give a poster or oral presentation of findings
Four-year college visits	Day-long campus visits consist of faculty- or graduate student-led research lab tours as well as engaging interaction with financial aid staff, transfer admissions staff, Peach State LSAMP scholars, and STEM faculty and graduate students conducting research in the students' areas of interest at those institutions
STEM industry tours	Students engage with scientist and engineers in behind-the-scene tours at STEM-related manufacturing and research and development facilities

Bridge mentoring activities include the following methods and mentoring models:

- **Faculty mentoring**–Faculty meet with students daily to guide, monitor progress, advise, provide support, answer questions, and address concerns about research problems and processes.
- **Peer mentoring**–Transfer Bridge students major in a range of STEM disciplines and provide guidance, tutoring, and advice as student leaders for their peers. Depending on the type of problem being addressed, a student may take on the role of mentor and possibly the reverse in which she may take on the role of mentee throughout the 3-week program.
- **Mentoring Network**–Faculty and Student-learning communities work together on multidisciplinary scientific problems. Integrated teams have either one or more STEM faculty and up to four students to work collaboratively on a specified research project. Hence the students develop lasting relationships with mentoring networks of both peer- and faculty-mentors.

Research Experience

The Transfer Bridge research experiences provide real-world research projects with faculty mentors in order to build foundational research skills for the Transfer Bridge students. The research training and engagement is accomplished using "mini" research projects that can be accomplished in 3 weeks. Research experience is intended to excite and encourage the Transfer Bridge students to persist in their STEM fields. Through hands-on research engagement, the students acquire the following skills: 1) Ability to conduct a literature search and develop a hypothesis, 2) Ability to conduct research design and statistical/analytical methods, 3) Ability to present data in oral and written formats, and 4) Knowledge of laboratory safety and ethical issues in science. The faculty mentors also assist the students in identifying and applying for summer internships at major research universities.

The specific objective of the research experience is to provide STEM students at 2-year colleges an engaging interaction with a faculty-led research project that they may not typically have at a 2-year institution. The Transfer Bridge students are totally immersed in developing and implementing a scientific investigation while reviewing scientific literature based on the project they are assigned. Throughout the Transfer Bridge program, the students are required to maintain a legal, scientific research notebook and to conduct controlled research projects, including the reporting and analysis of data. Transfer Bridge students work both independently on research projects and collaboratively throughout the 3 weeks on a poster and PowerPoint presentation. At the Transfer Bridge closing program, each research team gives an oral presentation on its research investigation. Sample research projects are listed in **Table 2**.

Four-Year College Visits

Visiting 4-year institutions is a key strategy of support that enables successful 2-year to 4-year transitions. Day trips to one or two Peach State LSAMP senior institutions are taken during the Transfer Bridge program. The visit is jointly planned by the 2- and 4-year institutions. In order to prepare for the visit, Transfer Bridge students are provided a full agenda for the day and campus information, such as admissions and financial aid electronic links, prior to the visit. In addition, the 4-year partner institution arranges for one of their senior LSAMP scholars to serve as the tour guide for the entire visit, which kicks off with an opening session and welcome from the LSAMP Co-PI and or Director.

A typical visit includes meetings with financial aid and transfer admissions staff, two or three STEM research lab tours, lunch with the LSAMP Director from the 4-year institution, and an interactive "student-lead" session with a panel of the 4-year LSAMP students. Financial aid personnel provide the Transfer Bridge students with information regarding the financial aid process and deadlines and special scholarships that are available to STEM students. Admissions representatives discuss the transfer admissions procedures, transfer hours, GPA requirements, and application and file completion deadlines. During the research lab tours, the Transfer Bridge students engage with cutting-edge technology and faculty, researchers, and both graduate and undergraduate students. The visit ends with a candid discussion with a panel of LSAMP students representing a diverse mix of STEM disciplines from the 4-year institution. The Transfer Bridge students gain meaningful information about the Classes, Student Life, Personal Experiences, and Campus Culture.

STEM Industry Tours

The industry tours offer Transfer Bridge students an opportunity to see exciting STEM processes and applications while engaging with Scientists, Researchers, Engineers, and Project Managers. The students learn about innovative ideas and witness problem-

TABLE 2 | Sample GSU-PC transfer bridge research projects.

Sample transfer bridge research projects	Research teams
Verification of pGreen map in transformed *Escherichia coli*	4 GSU-PC Faculty and 3 Transfer Bridge Students
Determination of sugar content in sodas	2 GSU-PC Faculty and 4 Transfer Bridge Students
Electrochemistry and battery technology	2 GSU-PC Faculty and 3 Transfer Bridge Students
Investigating the effects of environmental noise on bird songs, part 3–a continuing comparison of different bird species	1 GSU-PC Faculty and 3 Transfer Bridge Students
Environmental factors affecting spore germination of sensitive fern (*Onoclea senibilis*)	2 GSU-PC Faculty and 3 Transfer Bridge Students

TABLE 3 | Typical GSU-PC transfer bridge daily activities–Microbiology research project.

Week	Day	Work
0	Wednesday	• Mandatory orientation • Introduction to project
1	Monday	• Select samples and who is responsible for collecting them • Practice Gram staining from pre-cultured TSA.
	Tuesday	• Prepare samples (for grinding, add 5 ml of sterile water to 250 g of food) • Inoculate ONPG-MUG tests (100 ml of water directly for water samples; for food samples use 5 ml of supernatant to 95 ml sterile water) • Serial dilutions and plating of 100 µl for dilutions 10^{0} (100 µl directly from water sample or food supernatant), 10^{-01} (1 ml of water/supernatant to 9 ml of sterile water), 10^{-02} (1 ml of water/supernatant to 9 ml of sterile water) on EMB plates. Store plates at 37°C, read at 24/48 h
	Wednesday	• Record serial dilution/plate count results for 24 h • Record ONPG-MUG coliform test for 24 h
	Thursday	• Record serial dilution/plate count results for 48 h • Record ONPG-MUG coliform test for 48 h • Spread plate selected ONPG-MUG samples (two from each sample, 16 samples = 32 plates) for isolation of individual colonies on EMB. • Work on PowerPoint and poster
	Friday	• Tour: Oak Ridge National Laboratory
2	Monday	• Inoculate TSB for antibiotic sensitivity testing from EMB plates (16 colonies) • Inoculate TSA slants for Gram staining from EMB plates (16 colonies) • Work on PowerPoint and poster
	Tuesday	• Inoculate MHA agar for antibiotic sensitivity testing from TSB. • Perform gram stains • Work on PowerPoint and poster
	Wednesday	• Record antibiotic sensitivity testing results for 24 h • Perform Gram stains • Work on PowerPoint and poster
	Thursday	• Record antibiotic sensitivity testing results for 48 h • Work on PowerPoint and poster
	Friday	• University of Georgia Research Lab Tours
3	Monday	• Memorial day
	Tuesday	• Work on PowerPoint and poster • Practice presentation
	Wednesday	• Work on PowerPoint and poster • Practice presentation
	Thursday	• Work on PowerPoint and poster • Practice presentation
	Friday	• Transfer Bridge Closing Program Oral Presentations

solving approaches in action. These experiences demonstrate the value of their foundational core technology and math and science classes while inspiring them to finish their STEM degree. Seeing the industry processes along with one-to-one conversations with STEM professionals promote understanding and often introduce them to career pathways that they did not know exist. Typical STEM Industry Tours include Automobile and Aircraft Manufacturing Plants, Food-Processing Manufacturing Plants, Textile Manufacturing Plants, Battery Research and Development Facilities, Department of Energy National Laboratories, Technology Design Facilities, Waste-Water Treatment Plants, and Marine Science and Fishery Facilities.

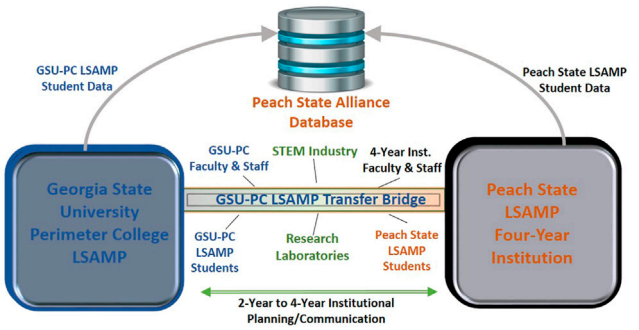

FIGURE 1 | Ideal GSU-PC transfer bridge process.

Student Recruitment and Selection

GSU-PC LSAMP scholars are eligible to participate in the Transfer Bridge Program. In order to be a LSAMP scholar, the student must have at least a 2.7 GPA, be enrolled full-time in a STEM discipline at GSU-PC, and have less than 70 credit hours. In addition, students must be a member of an underrepresented population in STEM as specified by the grant funder, including American-Indian, Alaskan-Native, African-American, Hispanic/Latino, or Native Hawaiian or other Pacific Islander. The GSU-PC LSAMP Campus Coordinators recruit students for participation in the Transfer Bridge program by marketing the opportunity, and students self-select to apply.

Implementation Details

The Transfer Bridge Program is hosted on one or more of the GSU-PC commuter campuses immediately following the spring semester. There are typically a cohort of 8–12 participants to engage with four or more faculty for three intense weeks of collaborative learning, research investigation and laboratory work, and field trips. The students are subdivided into smaller teams to work on faculty-led research problems. The type of research project dictates the specific daily activities, but each participant is required to work in the lab or the field each day (Monday–Friday) for a minimum of 4 hours. Most of the students tend to work on their research projects 8 hours or more per day. The field trip days include tours to STEM corporations and visits to Peach State LSAMP 4-year college campuses as described earlier. **Table 3** describes the daily tasks.

The typical costs for the Transfer Bridge program include pay for faculty, stipends for students ($500–$1,000 per student), research materials and supplies, and travel costs for field trips and campus visits. The travel costs vary depending on whether the trips require overnight stays in hotels and per diem costs. It is important to plan the research projects well in advanced to ensure that needed materials and supplies are available and committed faculty-mentors are available to lead the research activities.

Concurrent Interventions

The Transfer Bridge students are GSU-PC LSAMP scholars, so each participant has engaged in the LSAMP programming for at least one semester. The GSU-PC LSAMP programming includes the following:

- Academic Advisement
- Professional Development Workshops
- Scientific Seminars and Technology Talks
- Service Learning Projects (7 h/semester)
- Academic Support (Tutoring, STEM Labs, Drop-In Centers, Group Study)
- Alumni Panels/Seminars
- Peach State LSAMP STEM Innovators Conference
- Student Networking Events
- Access to Research and Internship Opportunities
- Student Stipends

Ideally, the Transfer Bridge students can choose to transfer to the one of the Peach State Alliance 4-year institutions. So if they do, they will be integrated into the LSAMP program at the transfer institution. **Figure 1** depicts the "ideal" Transfer Bridge Process with follow up and concurrent LSAMP engagement for the students. When a Transfer Bridge student enrolls at a Peach State LSAMP 4-year institution, their data in the Peach State Alliance Database is updated such that the transfer institution will become the owner of the student data and continue to update the student's file (LSAMP activities, mentors, student progress) until their graduation.

Research Methods

To better understand the success of the GSU-PC Transfer Bridge Program in supporting the Peach State LSAMP's goal to extend the STEM pipeline, the Alliance research team led by Dr. Karen DeMeester conducted an exploratory and descriptive study of the program. The research study examined the rates of Transfer Bridge Program participants' 1) enrollment in 4-year institutions, 2) pursuit of STEM degrees at 4-year institutions, 3) attainment of undergraduate degrees in STEM disciplines, and 4) enrollment in graduate degree programs in STEM-related disciplines. We also examined enrollment and degree attainment in general as well as STEM-specific disciplines. The Transfer Bridge participants' outcomes were compared to a group of GSU-PC students who were eligible for participation in Transfer Bridge but who did not participate in the program. The study is an exploratory and descriptive study that employed a comparison group to provide context and to improve understanding of program outcomes. The use of secondary data, however, did not enable us to control completely for differences amongst our groups, and therefore results of the study are not generalizable and do not evidence impact. To obtain additional context, we also surveyed Transfer Bridge participants to learn what aspects of the program they perceived as most beneficial and supportive of persistence in college completion in general and achieving college degrees in STEM fields specifically.

Data Collection

A data sharing agreement was executed between the University System of Georgia (USG) and the University of Georgia, and a request for enrollment, degree award, and demographic data for Transfer Bridge participants and a comparison group of GSU-PC students was submitted to USG's Research and Policy Analysis department. The Peach State LSAMP Director and

the Transfer Bridge Program Director compiled the names and student identification numbers of all students who participated in Transfer Bridge from its first year in 2009 through 2019. Due to COVID-19 restrictions, the program was altered and conducted virtually in summer 2020. The Peach State LSAMP Director submitted the student information to USG through its secure file transfer system. Through the same secure transfer system, USG provided research analysts at UGA's Carl Vinson of Institute of Government de-identified data (stripped of names and identification numbers) for the Transfer Bridge participants along with a comparison sample of GSU-PC students that met the eligibility requirements for participating in Transfer Bridge but did not participate in the program. To participate in Transfer Bridge, a student had to be from a historically underrepresented population in STEM, United States. citizen or resident alien, and enrolled full-time in an associate-level degree in STEM at GSU-PC. The research analysts compiled and analyzed the data and only reported results at an aggregate level. The program Directors who submitted the list of students including the names and identification numbers did not have access to the data received from USG, and the research analysts that received the data from USG did not have access to the list of participant names and identification numbers submitted to USG. The USG data are limited to public institutions within Georgia and do not, therefore, include data on students' enrollment and degree attainment in private institutions in Georgia (e.g., Emory, Morehouse, and Mercer universities) or any institutions outside of Georgia.

To triangulate and supplement the USG data results, Transfer Bridge participants from 2009–2018 were invited to participate in a survey to 1) track their post-program enrollment in bachelor's and post-bachelor's degrees, degree completion, and areas of study; 2) track their post-program participation in research; and 3) gain insight into participants' perceptions of how Transfer Bridge influenced their academic persistence, especially in STEM. The survey was administered through the Qualtrics survey platform, and Transfer Bridge alumni responded to the survey from April 15, 2019 through May 9, 2019.

Sample

The USG data set yielded data for a sample of 85 Transfer Bridge students and 71,301 non-Transfer Bridge students. Overall, students included in the sample were primarily Black or African American (71.9%), and there was no significant difference in race/ethnicity, high school GPA, or first-generation status between Transfer Bridge and Non-Transfer Bridge participants. Students in both samples were predominantly citizens (89.1%); however, the Transfer Bridge sample had a significantly higher proportion of resident aliens (43.5%) than the non-Transfer Bridge sample (10.8%). Proportionally, there were significantly more males participating in Transfer Bridge (50.6%) than in the non-Transfer Bridge group (38.7%).

Analysis

We used SPSS to perform chi-square tests on the USG student data to examine statistically significant differences in the rates of enrollment and degree completion for Transfer Bridge and non-Transfer Bridge participants. For the Transfer Bridge alumni survey, we used SPSS to calculate frequencies and means, and we analyzed open-ended comments for patterns and emergent themes.

RESULTS

Results of University System of Georgia Data

Results of our analyses showed statistically significant differences for outcomes related specifically to STEM enrollment and degree completion. As **Table 4** shows, Transfer Bridge participants were significantly more likely to enroll in a 4-year STEM program, receive a STEM Bachelor's degree, enroll in a post-baccalaureate STEM program, and receive a STEM post-baccalaureate degree than non-Transfer Bridge students. There were no significant differences between Transfer Bridge and Non-Transfer Bridge students for non-STEM specific enrollment or completion of non-STEM degrees (bachelor's or post-baccalaureate). The only demographic differences found were that Transfer Bridge students were more likely to be resident aliens and males than the non-Transfer Bridge students. High School GPA was close to being significantly different but remained just above the 0.05 threshold.

Results should be interpreted with caution, however, because all significant results had small expected cell counts. The expected count for STEM bachelor's enrollment among Transfer Bridge students was *just* less than 5 (4.2 students), while the expected counts in the other outcomes for Transfer Bridge students ranged from 0.1 to 1.3. This is likely due to both the relatively small number of Transfer Bridge students (85 compared to the 71,301 non-Transfer Bridge students) and that STEM enrollment/degree receipt were relatively uncommon events for the non-Transfer Bridge students. Since the larger group engaged in these STEM events at such a small rate, it created small marginal percentages resulting in small expected cell counts in the smaller group. Analyses where cell counts were less than five were for dichotomous outcome variables and, therefore, were not able to be further consolidated into categories to address small expected cell counts. Again, given the small expected cell counts, these results should be interpreted with caution.

Results of Transfer Bridge Alumni Survey

Summary

Forty-three alumni of the Transfer Bridge Program responded to the survey from April 15, 2019 through May 9, 2019. **Figure 2** shows the number of alumni who responded from each cohort year. The majority of respondents (58%) participated in Transfer Bridge during the last 5 years. Sixty-five percent (65%) of the alumni (28) who responded to the follow-up survey reported being currently enrolled in an institute of higher education while 35 percent (15) said they were not currently enrolled in school. **Table 5** shows the information for the 28 alumni currently enrolled, including the year they participated in Transfer Bridge, the institutions

TABLE 4 | Results from USG data analyses.

Outcome	Non-Transfer bridge		Transfer bridge		Total		Chi-square	Sig
	N	%	*N*	%	*N*	%		
Enrolled in a non-STEM Bachelor's Program	12,442	17.4	14	16.5	12,456	17.4	0.057	0.812
Enrolled in a STEM Bachelor's Program	3,483	4.9	45	52.9	3,528	4.9	417.347	0.000[a,b]
Conferred a non-STEM Bachelor's Degree	5,432	7.6	4	4.7	5,436	7.6	1.024	0.312
Conferred a STEM Bachelor's Degree	1,083	1.5	29	34.1	1,112	1.6	588.342	0.000[a,b]
Enrolled in a non-STEM Post-Bachelor's Program	713	1.0	2	2.4	715	1.0	1.567	0.211[b,c]
Enrolled in a STEM Post-Bachelor's Program	93	0.1	4	4.7	97	0.1	130.979	0.000[a,b,c]
Conferred a non-STEM Post-Bachelor's Degree	373	0.5	0	0.0	373	0.5	0.447	0.504[b,c]
Conferred a STEM Post-Bachelor's Degree	41	0.1	3	3.5	44	0.1	166.137	0.000[a,b,c]

[a]*The Chi-square statistic is significant at the .05 level.*
[b]*More than 20% of cells in this subtable have expected cell counts less than 5. Chi-square results may be invalid.*
[c]*The minimum expected cell count in this subtable is less than one. Chi-square results may be invalid.*

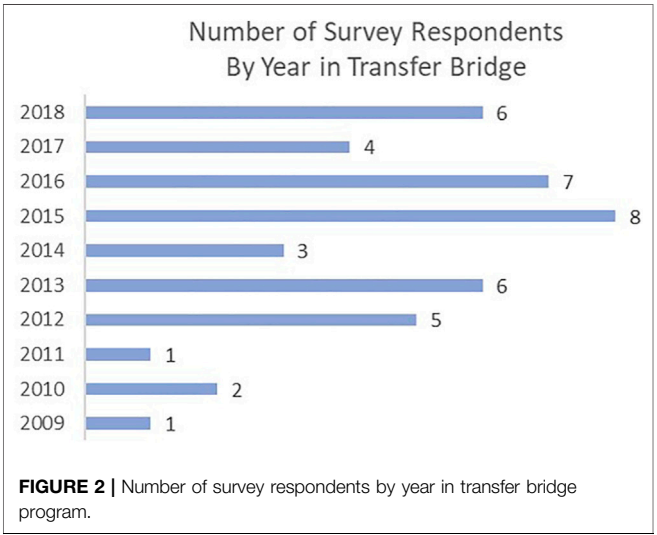

FIGURE 2 | Number of survey respondents by year in transfer bridge program.

where they are enrolled, degrees they are pursuing, and their area of study/major. The information presented is from alumni who participated in Transfer Bridge program from 2011 to 2018. All 15 respondents who are not currently enrolled in higher education reported having already graduated. Of the 15, three provided no additional information while the other 12 provided the information presented in **Table 6**. Of the 12, nine indicated they intend to apply to graduate or professional programs in the future.

Overall, Transfer Bridge alumni commented that their experiences in the program contributed to their persistence in STEM education and pursuit of STEM careers. Specific experiences mentioned were opportunities to apply principles learned in the classroom, learn programming, work in a research lab, attend conferences, and network with mentors and professionals in the field. When asked what aspects of the program had the greatest influence on their Academic Careers, Alumni mentioned Research Experiences, Mentorship and opportunities to engage with faculty and advisers, visits to 4-year institutions, and support with recommendations. Alumni concluded that the most influential elements of the program on STEM persistence were exposure to new STEM areas of study and career fields, opportunity to use and gain experience with lab equipment and techniques, increased understanding of what specific disciplines and fields they wanted to pursue, increased confidence to pursue education and careers in research, increased competencies and skills (e.g., time management, work ethic) needed to succeed in advanced education, and increased interest in STEM research, education, and careers.

Full Results

Transfer Bridge Alumni were asked if any of their experiences in the program contributed to their persistence in obtaining their degrees, comments include the following:

- My current position at my job is because of what I did during the Summer Bridge Project I did back in (GSU-PC).
- The Transfer/Summer Bridge Program allowed the practical application of principles learned, during lectures and labs, to relatable experiences, which influenced my decision to pursue/obtain multiple STEM degrees.
- Inspired me to pursue a career in Engineering.
- Transfer/Summer Bridge Program introduced me to programming which emphasized my desire to become a Software Engineer.
- Mentoring
- My research experience from working in the Research Lab, Attending Conferences and Networking with Mentors and Professionals in the field contributed to my desire to obtaining a STEM-related degree.
- The summer Bridge Program greatly helped me in pursuing a STEM career
- Yes
- It definitely did. I was able to define my future goals and narrow down my path
- (GSU-PC) Transfer/Summer Bridge Program provided me coaching/mentoring and research experience that helped me throughout my undergrad program.

Alumni not currently in an educational program were asked what influenced their decision not to continue their education at

TABLE 5 | Information from Transfer Bridge Alumni Currently Enrolled in.

Institution	Degree	Area of study
University of Michigan	Doctoral/Ph.D	Mechanical Engineering
Lake Erie School of Osteopathic Medicine	Doctoral/Ph.D	Pharmacy
Georgetown University School of Medicine	Professional	Doctor of Medicine (MD)
Georgia Institute of Technology	Masters	Electrical Energy and Telecommunications
Massachusetts Institute of Technology	Doctoral/Ph.D	Biology (focus in Structural Biology)
The Geisel School of Medicine at Dartmouth	Doctoral/Ph.D	Not chosen a specialty yet, but considering Neurosurgery or Neurology
Lake Erie School of Osteopathic Medicine	Professional	Pharmacy
Georgia Institute of Technology	Bachelor's	Computer Science
Kennesaw State University	Bachelor's	Mechanical Engineering
Georgia Southern University	Master's	Pharmacogenomics and Translational/Precision Medicine
Georgia Institute of Technology	Doctoral/Ph.D	Electrical Engineering
University of Pittsburgh	Professional	Dental Medicine
Georgia Institute of Technology	Bachelor's	Chemical and Bio-molecular Engineering
Georgia Institute of Technology	Bachelor's	Electrical Engineering
Georgia Institute of Technology	Bachelor's	Civil Engineering
Georgia Institute of Technology	Bachelor's	Electrical Engineering
Georgia Institute of Technology	Bachelor's	Chemical and Bio-molecular Engineering
Manchester University	Professional	Pharmacy
Georgia Institute of Technology	Bachelor's	Computer Science
Kennesaw State University	Bachelor's	Civil Engineering
Georgia Institute of Technology	Bachelor's	Electrical Engineering
Georgia Institute of Technology	Bachelor's	Industrial Engineering
Georgia State University	Associates	Biology
Georgia State University	Associates	Biology
Georgia State University	Bachelor's	Computer Science
Georgia State University	Bachelor's	Biology
Mercer University	Bachelor's	Mechanical Engineering
Georgia State University	Doctoral/Ph.D	Biology

TABLE 6 | Information from transfer bridge program alumni who graduated and are not currently enrolled in higher education.

Institution	Area of degree	Do you plan to enroll in a graduate or professional degree program?	Intended area of study
University of Georgia	Dual Bachelors in Microbiology and Biological Science	No	
Georgia Institute of Technology	Biochemistry	No	
University of Georgia	Environmental Health	Yes	Pharmacy
Georgia Institute of Technology	Electrical Engineering	Yes	Electrical Engineering
Georgia State University- Perimeter College	Biology	Yes	Doctor of Pharmacy
Georgia Institute of Technology	Mechanical Engineering	Yes	IT
Kennesaw State University	Computer Science	Yes	Management
University of Georgia	Biochemistry and Molecular Biology	Yes	Doctorate in Pharmacy (Drug therapy and development)
Georgia Institute of Technology	Electrical and Computer Engineering	Yes	PhD in Control Systems Engineering
Georgia Institute of Technology	Computer Engineering	Yes	Computer Science
Georgia Institute of Technology	Mechanical Engineering	No	
University of Southern California	Mechanical/Petroleum Engineering	Yes	Petroleum Engineering

this time, four of the respondents presented in **Table 6** provided the following comments:

- There are a lot of Good Opportunities in my field with a Bachelor's degree. I want to gain industry experience to find out what I want to pursue and decide whether I want to pursue a graduate degree.
- Personal decision (i.e., age, family, career field), and the fact, additional education would not influence promotion potential, in my current career field.
- Ongoing continuing Ed for current job is sufficient
- I am planning to work for 2 years and come back to school to get my masters.

A goal of the Transfer Bridge Program is to encourage and prepare students to participate in additional research training experiences and to do additional work in a research laboratory setting. Transfer Bridge Alumni were asked whether or not they had participated in additional research training since completing the Transfer Bridge Program. Sixteen Alumni responded to this item. Of the 16, only five indicated

they had participated in additional research training. Three of the five provided the following descriptions:

- Currently taking research methods in college for Computer Science.
- I learned about Robotic Operating System, some controls, Linux Operating System, Robot Setups and Demo, and ESM usage.
- I participated in a Research Experience for Undergraduates at Lehigh University in Pennsylvania during summer 2016 right after my Summer Bridge Experience. Participating in the Summer Bridge before my REU prepared me for my REU experience.

Alumni were also asked if they had worked in a research lab since participating in Transfer Bridge. Fifteen respondents answered this survey item: Eight respondents reported not having worked in a research lab while seven reported they had additional lab experience. Of those that said "Yes," four described his/her experience. The comments are as follows:

- Currently I work in a research lab. We work on Battery Technology and Electrochemistry. I've been introduced to different types of machinery. I've learned Data Analysis through these machines. I've also been able to apply the things I've learned during the Summer Bridge Program and in my courses.
- Georgia Tech Robotics Department; Boston University Mechanical Engineering Department
- I was working as a lab assistant in one of my Professor's lab last semester, and it changed my mind about going to graduate school. I am now definitely going to graduate school. Research and Lab experiences are eye-opening for me and many other students.
- Worked as a Research Assistant in inputting data from surveys taken from a specific population which studied mainly the patterns of bike riders.

Alumni were asked how their experiences in Transfer Bridge influenced their academic careers. Overall, the most influential outcomes of the program were exposure to new STEM areas of study and career fields, opportunity to use and gain experience with Lab Equipment and Techniques, increased understanding of what specific disciplines and fields they wanted to pursue, increased confidence to pursue education and careers in research, increased competencies and skills (e.g., Time Management, Work Ethic) needed to succeed in advanced education, and increased interest in STEM research, education, and careers. Thirty-Two of the 43 survey respondents (74%) provided the following comments:

- Helped me to get exposure with a PLC device.
- It helped me maintain and formulate a structure as well as Time Management Skills. It has also helped in the research course I am currently taking.
- It gave me exposure to academic research.
- I have learned the importance of doing undergraduate research not only for my resume but for life in general. I learned how to use many things in a lab that I will be working with for the last 2 years of my bachelor's degree.
- It was a Tremendous Benefit to have some kind of technical experience after my first year in college. It really helped me in my application for a DHS summer internship program. If I didn't have that opportunity I don't know if I would have enough to talk about in my application. I enjoyed the program so much that I changed my major to something more related to the project.
- The Transfer/Summer Bridge Program reinforced work ethics, which allowed me to graduate Cum Laude, with Dual-STEM Bachelor Degrees.
- I had an opportunity to experience what a research program is like. It helped me get over some anxiety that I felt in regards to research.
- It exposed me to a cutting edge research field in the area of renewable energy. I had the opportunity of working on Piezoelectricity which helped me in transferring to Georgia Tech and further strengthen my passion for Renewable Energy.
- It exposed me to the research field that I greatly appreciate.
- My experience in the Georgia State University-Perimeter College Transfer/Summer Bridge Program influenced my academic career in a lot of ways. It helped me to choose what I want to do in my career life. I wanted to study in the STEM field but I wasn't sure what I wanted to study. Summer Bridge Program helped me to pursue my career in Chemical Engineering. I am always grateful for getting that chance.
- It Showed me that you don't have to be a doctor to be successful. If being a doctor doesn't work there are a Million of other jobs in a STEM field.
- It was my first experience working in a lab. It gave me confidence that I can learn to work in a lab and feel comfortable in research settings.
- Research experience, Working in Teams, and Interest in STEM
- The Summer Bridge program exposed me to research and that made me more interested in Public Health
- It helped me to see that research is not for me so I decided to Pursue Medicine.
- It helped me significantly in getting the First-Hand Experience of what research entailed and What it required.
- Transfer/Summer Bridge introduced me to Programming Language (C++) which helped me succeed in the Programming Courses I took afterward.
- Perseverance to get through Tough Courses
- It was nice to have mentors that I could talk to about my Future Plans. People who cared about my success.
- During the Summer Bridge Program I developed a lot of skills that I didn't learn in my classes and that increased my interest in Electrical Engineering
- It made me more interested in pursuing a STEM related major and Furthering my Education to Graduate Level Degrees.

- My Experience in the Summer Bridge Program greatly influenced my Academic Career. I learned how to carry out a Short Research Project with a team. In addition, I learned how to think more critically about Scientific Experiments, Analyze Scientific Data, and Present my data at meetings. Without this program, I would not have pursued additional research experiences and most likely wouldn't have ended up at MIT for my PhD in Biology.
- The Research Experience I had and the results I obtained during the Summer Bridge Program allowed me to better fit into New Lab Groups and Excel. It made it easier to conduct undergraduate research during regular semesters in the school I transferred to which is essential for my graduate school application. I'd say the Georgia State University-Perimeter College Transfer/Summer Bridge Program initiated my interest in graduate school.
- It made me realize how exciting research is and that I wanted to pursue more of it.
- It made me more aware of the opportunities in the STEM field and informed me of ways to achieve them through the workshops and tours of STEM industries. Being part of the program brought me closer to peers who had the same interest and created the avenue to study together, work on projects and put our minds together.
- It gave me Great Experience and Increased My Desire
- My Experience helped me obtain a Bachelors in Biotechnology. Also in my current career path, my experiences have helped me. I gained skills that are applicable in various aspects of healthcare
- It Influenced my Career Choice
- Participating in the Summer Bridge Program helped influence my Academic Career. I was able to get an Internship through this program.
- The Summer-Bridge Program positively shaped my career in numerous ways. It gave me an opportunity to pursue scientific research for the first time, under the mentorship of great and wonderful scientists and mentors. It influenced my decision to transfer to a research-focused 4-year college (Emory University). Through these same opportunities, I continued to pursue my research interests and even founded a non-profit to provide similar research opportunities for young women in Ghana and Nigeria who are interested in pursuing STEM careers. After graduation from Emory, I did an NIH research fellowship for 2 years at Mount Sinai in New York before matriculating into medical school. While in medical school, I am still actively involved in research and will be doing a summer research fellowship at the NIH Neurosurgery Department. What started off as an 8 weeks summer research program has influenced the kind of physician I want to be.
- The Bridge Program was crucial in rendering my application competitive in both Undergraduate and Medical School. Also, it's important for me to underlie that, as an undergraduate, Perimeter College was the only school, where I had the opportunity to do research and apply the theories I learned in class in a laboratory setting. I loved the experience. This is why, as a medical student, I am leaning more toward a field that requires more research, Neurosurgery.
- The Research Experience was the biggest influence that I received from this program. The opportunity to work with researchers from GA tech helped me in my studies.

Transfer Bridge Alumni were also asked what aspects/components of the program had the greatest influence on their Academic Careers. The same alumni who responded to the question about the program's influence on their academic careers also provided comments about what aspects of the program were most impactful for them. Overall, Research Experiences, Mentorship and Opportunities to engage with faculty and Advisers, visits to 4-year institutions, and support with recommendations. Their comments are as follows:

- My Relationship with my mentor and the kind of project I was involved in, my STEM industry tours all contributed a big role.
- All parts had a huge impact but the research experience was the best because it helped me explore something I might be passionate about
- The Tours and College visits were instrumental for me to figure out how to use Academic and Non-Academic Resources in order to succeed in school and life afterward.
- My Relationship with my research advisor was great because she wrote me many recommendations for other research opportunities for this summer.
- The Part of the program that had the biggest impact was the mentorship from the professors. They gave me real responsibility and expected results, which really pushed me to learn. I especially enjoyed being able to present my research at the ACM Southeast conference where I was able to practice my public speaking skills. It was a great networking opportunity and gave me invaluable experience.
- No particular part of the program, had more of an impact, over the others. Each impacted my life in different ways.
- I learned more about Collecting Data, Writing a Report, and Giving a Presentation. I wish there were more computer science related projects. Because I felt many of them were focused on fields related to Biology or Chemistry instead of Technology. But the experience overall was great.
- All of it. Mentors believed in me and helped guide me, research gave insights on renewable energy, college visits helped with making a choice on major and passion, tours exposed me to Life as an Engineer.
- The Research Experience
- Research Experience, Relationships to Mentor.
- The Research Experience and Tour of STEM Industries.
- I Really enjoyed the mentoring. They help you plot out an academic evaluation to see which classes would best be put together. Since I had to double up on my Science Classes.
- Having Hands on experience with processes of research and learning how to work with a professor.

- Visits to Colleges and Universities, Research Experience, and Mentor
- Relationship with Mentors and Working in Groups made the most impact, as well as Oral and Poster Presentation
- Tour of Stem Universities had the Greatest Impact
- The Greatest Area of Impact was the Invaluable Experience I got from the research.
- I think every part of program had the greatest impact on me because there is always an opportunity to learn new things.
- All
- I would say visits to Colleges and Universities. It motivated me to apply a 4 years University.
- My Relationship with my Mentor, Gedeon helped me a lot when I transferred to Georgia Institute of Technology.
- There were two parts of the program that greatly impacted me which are the research experience and visit to Colleges and Universities.
- Research Experience overall (with my Mentors and Peers).
- The Greatest Impact for me I would say was the research project I was working on and my relationship with my advisor really. Those two parts increased my interest in Academic Research and Graduate School.
- The Research Experience.
- The Research Experience had the greatest impact because it exposed me to numerous opportunities that allowed me to gain lab experience, grow and also learn in the STEM field. Through it, I was able to obtain leadership skills, think independently, and work efficiently with diverse teams. In all, it was an experience I would always be grateful to have been part of.
- Research Experience.
- The research itself was a great experience, but the tours helped me shape my career path. Each tour gave me exposure to different STEM careers and I was able to see first-hand what each path has to offer.
- Tour of STEM industries, visit to Colleges and Relationship with Mentor.
- The visit to UGA had the greatest impact because we got to see UGA's Research Labs. It helped me understand that I wanted to do research in terms of my field. Also by going to UGA I was able to meet a faculty who forwarded my Resume, and thus provided me with an Internship.
- Our visits to Colleges and Presentations at conferences were the most impactful. It gave me an insight into 4 years colleges and ways I can continue to do research after transferring. Moreover, having the opportunity to present my summer work to peers and mentors was critical in my growth as a young scientist. It gave me the confidence I needed to continue to pursue a career in science. I had a wonderful relationship with my research mentor during the summer bridge program, and she continues to support me in all my career endeavors.
- My relationship with my mentor was amazing. In fact, we are still in contact till now. Also, the research experience was enjoyable and challenging at the same time. I enjoyed the fact that I was waking up every morning to go do what I love. I would give anything to be part of it again.
- Research Experience had the Greatest Impact.

Limitations

A key limitation of the study was the limited sample size of Transfer Bridge participants. A total of only 114 students have participated in the Transfer Bridge Program (2009–2018), and of those, we were only able to obtain data for 85 (75%). In addition, we were unable to obtain data (e.g., National Student Clearinghouse Student Tracker Data) on participants who enrolled and graduated from Institutions outside of the University System of Georgia, including private institutions within the state (e.g., Emory) as well as Institutions outside of Georgia. While the alumni survey provided some of the data, we realize that response bias potentially exists with self-report data. Furthermore, those alumni who chose to respond to the survey could be more likely to represent those with positive outcomes (successful STEM degree enrollment and graduation) than those who chose not to respond. It is likely that Transfer Bridge participants were already predisposed to be successful. Transfer Bridge participants had to already be a member of the Peach State LSAMP program at GSU-PC and then self-select into the supplemental Transfer Bridge summer program. To participate in Peach State LSAMP, students already had to be high performing academically and motivated. There were no significant differences, however, between Transfer Bridge and Non-Transfer Bridge participants in high school GPA.

Another limitation was the USG data did not specify major for GSU-PC associate degrees. As a result, we were not able to limit the non-Transfer Bridge comparison group to just those students enrolled in a STEM-focused major. It is plausible that the comparison group contained a number of students who were not interested in STEM or pursuing STEM areas of study and were, therefore, less likely to pursue future STEM education.

DISCUSSION

Outcomes and Implications

The GSU-PC Transfer Bridge Program aims to increase the number of Peach State LSAMP scholars who transfer to 4-year Peach State Alliance (and other) Colleges and Universities and to increase the likelihood that they persist and graduate with a baccalaureate degree in a STEM discipline. The program employs key strategies for supporting student success and persistence in STEM, including mentorship, opportunities to gain research experience, visits to 4-year Colleges and Universities, and tours of STEM industries. We conducted a preliminary exploratory and descriptive study to examine the relationship between participation in the Transfer Bridge Program and higher rates of 1) Enrollment in 4-year institutions, 2) Pursuit of STEM degrees at 4-year institutions, 3) Attainment of Undergraduate Degrees and Undergraduate Degrees in STEM Disciplines, and 4) Enrollment in Graduate Degree Programs and STEM-related graduate degree programs. University System of Georgia Enrollment, Degree Attainment, and Demographic Data were obtained, and the data set yielded a sample of 85 Transfer Bridge

Students (75% of all students who participated in the program from its inception) and a comparison sample of 71,301 GSU-PC students who met the minimum eligibility criteria to participate in the Transfer Bridge Program but who chose not to participate. Chi-Square Tests were used to examine statistically significant differences in rates of Enrollment and Attainment of Baccalaureate and Post-Baccalaureate Degrees for the Transfer Bridge and Non-Transfer Bridge Participant Groups. Results of the analyses indicated that Transfer Bridge participants were significantly more likely to enroll in a 4-year STEM program, receive a STEM Bachelor's Degree, Enroll in a Post-Baccalaureate STEM program, and Receive a STEM Post-Baccalaureate Degree than non-Transfer Bridge Students.

To triangulate and supplement the USG data results, we invited Transfer Bridge participants from 2009–2018 to participate in a survey about the benefits of specific components of the program and the quality of implementation of those components. The majority of the alumni who responded to the survey (65%) reported being enrolled in an Institute of Higher Education. Half of those students were enrolled in bachelor's degree programs with a STEM major, and 43 percent were enrolled in post-baccalaureate programs with a STEM area of focus. When asked what, if any, aspects of the program influenced their persistence in STEM education, Alumni cited the Mentorship, Research Experiences, Opportunities to attend conferences and to network, and technical skills gained during the program. Alumni were also asked how their experiences in Transfer Bridge influenced their academic careers. Overall, the most influential aspects of the program were exposure to a variety of STEM disciplines and career fields; Opportunities to gain academic and Research Competencies, Skills, and Techniques; Clarity about what disciplines and fields they wanted to Pursue, and increased confidence to pursue education and careers in STEM.

Results of the Transfer Bridge study provide increased understanding of what outcomes are most critical for supporting the transfer of historically underrepresented students in STEM from 2-year to 4-year institutions and their successful completion of STEM degrees. Critical outcomes include basic research understanding and skills, confidence to engage with faculty mentors, sense of preparedness to participate in cutting-edge research, and increased awareness of STEM career pathways. Key components of a STEM bridge program targeting transfer students include research experiences, mentorship and opportunities to engage with faculty and advisers, and visits to 4-year institutions. In addition, this article provides detailed information for implementing the Transfer Bridge Program and its components. Programs interested in creating and implementing similar bridge programs may benefit from the detailed discussion of the logistics.

Next Steps

To extend and improve on the preliminary results of this study, we will request USG data for a comparison group of just GSU-PC LSAMP students from 2009–2018 who chose not to participate in the Transfer Bridge Program. This more specific comparison group will enable us to examine differences in rates of STEM enrollment and degree attainment between groups of students who have all demonstrated an interest in pursuing STEM-specific education programs. Through this approach, we will also be able to examine whether there are statistically significant differences between LSAMP students who chose to participate in Transfer Bridge Program in addition to their regular LSAMP activities and those who did not chose to participate.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because This is confidential student data that must have the expressed permission from the University System of Georgia to share. Requests to access the datasets should be directed to Leslie Hodges, leslie.hodges@usg.edu.

ETHICS STATEMENT

The study was submitted to the University of Georgia Institutional Review Board. Upon review of the application, the study was deemed exempt from meeting the requirements of the federal regulations for human subjects protections.

AUTHOR CONTRIBUTIONS

AB, KD, and MM made a substantial, direct and intellectual contribution to the work, and approved it for publication. BS cleaned the proprietary student data, ran the data analysis, and interpreted the results and limitations.

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