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Impact of an intensive multi-disciplinary STEM enrichment program on underrepresented minority student success

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Abstract

Purpose – This study examines the impact of participation in a STEM Enrichment Summer Bridge Program, funded by the NSF Houston-Louis Stokes Alliance for Minority Participation, on undergraduate student success outcomes, particularly for under-represented students.

Design/methodology/approach – The study uses propensity score matching and logistic regression analysis to examine the effects of participation in the STEM enrichment program on graduation and retention in STEM after matching on baseline socio-demographic and pre-college characteristics.

Findings – The analysis found that program participation had a significant effect on increasing both the graduation rates and retention of under-represented minority students in STEM fields. In addition, results indicated that program participation had a particularly strong impact for Pell-eligible students in terms of course grades.

Research limitations/implications – Data obtained for this study were limited to a single Hispanic-serving/Asian-serving institution, and therefore are not necessarily representative of the graduation and retention trends of the larger population of underrepresented minority (URM) students across the nation.

Originality/value – This study uniquely adds to the existing body of literature surrounding the retention of URM students in STEM fields by accounting for baseline variables, such as pre-college academic achievement and socio-demographic characteristics, that could lead to bias in estimating results. Specifically, this study addresses limitations of previous studies by comparing participants and non-participants of the STEM enrichment program who are matched on a selection of baseline characteristics.

Keywords STEM education, Underrepresented racial minorities, Student success, Achievement gap

Paper type Research paper

Introduction

Despite racial and ethnic population changes, achieving diversity in STEM undergraduate education remains a pressing challenge in today's higher education landscape (National Board of Sciences, 2010; Allen-Ramdial and Campbell, 2014; Riegle-Crumb *et al.*, 2019).

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Recently, a growing body of research has focused on the educational disparities between students in STEM fields across several demographic variables, specifically race, gender and socio-economic background (Riegle-Crumb and King, 2010; Eagan *et al.*, 2013; Griffith, 2010). The importance of addressing educational disparities was emphasized, in part, by the US government, who made an expressed call to increase STEM workforce diversity in order to maintain the nation's position as global leader in scientific and technological innovations (Lane, 2016; NSF, 2014). The number of STEM jobs is projected to grow between 9% and 15% within the next decade, with 99% of these employment opportunities requiring a postsecondary degree or certificate. Despite these projections, wide gaps in the participation of underrepresented minority (URM) groups in the STEM workforce remain.

In the 2015–2016 academic year, 8.5 and 12.7% of STEM degrees were awarded to black and Hispanic students, respectively, compared to 62.6% awarded to white students (NCES, 2018). Currently, under-represented minority students are the fastest growing segment across the nation, yet remain the least represented in STEM fields (Institute of Medicine, 2011; Toven-Lindsey *et al.*, 2015). Several studies have demonstrated that URM students enroll in STEM fields at comparable rates to their white peers, yet a continuous pattern of early attrition and low graduation rates exist among URM students (NSF, 2014; Tsui, 2007). These findings provide clear evidence of the need for strong intervention strategies that can increase the persistence, retention and diversity of URM students throughout the STEM pipeline.

Purpose of the study

STEM enrichment programs, in recent years, have been employed to serve several objectives related to student retention and success, primarily in attracting students toward STEM fields, providing undergraduate training opportunities and increasing both k-12 and higher education institutions' ability to promote student entry and success into STEM education and subsequently, the STEM workforce (Rincon and George-Jackson, 2016). In this study, the role of a STEM intervention program in increasing persistence, graduation and diversity of URM students in the STEM pipeline is examined (Carpi *et al.*, 2017; Estrada, 2014; Hurtado *et al.*, 2010; Lane, 2016). Specifically, this study focuses on the role of the UH Scholar Enrichment Program at improving the graduation rates and course grades of URM students enrolled in STEM fields, which has been supported by various studies comparing the success rates of similar programs at fulfilling this particular objective of STEM enrichment programs (e.g. Gilmer, 2007; Lee and Harmon, 2013; Jackson and Winfield, 2014). Yet few studies examine the success of these programs using methodologies that use matched data sets to account for confounding variables, such as socioeconomic impacts, that may lead to bias in estimating results (Gonyea and Miller, 2011; Chinn *et al.*, 2007). URM students often voluntarily self-select into STEM enrichment programs, therefore it is difficult to account for differences between program participants and non-program participants when assignment is not random (Windsor *et al.*, 2015; Wischusen *et al.*, 2011). Given the importance of STEM intervention programs at bridging the gap in the educational achievement of URM students, this study aims to examine the impact of the University of Houston (UH) Scholar Enrichment Program (SEP) Summer Bridge at improving the successful completion rates of first time in college freshman minority students enrolled in the University of Houston, in STEM undergraduate degrees after controlling for key socio-demographic and pre-college factors. In particular, our study addresses the following research questions:

(1) Relative to their non-participating peers, to what extent does participation in the UH Scholar Enrichment Program Summer Bridge have an association with degree completion?

(2) Relative to their non-participating peers, to what extent does participation in the UH Scholar Enrichment Program Summer Bridge have an association with student retention?

(3) Relative to their non-participating peers, to what extent does participation in the UH Scholar Enrichment Program Summer Bridge have an association with successful course completion rates in the large enrollment freshman STEM Calculus 1, Chemistry 1 and Biology 1 courses?

This study pays particular attention within each question to the extent to which Hispanic and African-American students' outcomes vary relative to their peers in the SEP Summer Bridge. Additionally, analyses were conducted specifically with Pell eligible students to investigate the influence of program participation on the course grades and GPA of this particular segment of students. Findings from our research study contribute to the growing body of research that examines best practice principles in STEM undergraduate education and program evaluation that will improve rates of degree completion and subsequent entry into STEM graduate fields of study among URM students. From a broader perspective, these principles may ultimately contribute to the development of a diverse and adequately trained domestic workforce. Achieving a well-trained STEM workforce that truly reflects the state's demographics ensures that the state of Texas can tackle challenges concerning healthcare improvement, technological advances and excellence in research, and could serve as an example to other states where the transition in demographics is occurring at a slower pace.

UH scholar enrichment program

The UH Scholar Enrichment Program Summer Bridge was instituted as part of the National Science Foundation's Louis Stokes Alliance for Minority Participation (LSAMP) with the shared goal of increasing the quality and quantity of under-represented minority students persisting and graduating in STEM fields. Each summer, approximately 50 students from the College of Natural Sciences and Mathematics, College of Engineering and the College of Technology were invited to participate in the program. Students that were admitted to a STEM college after a special admissions review because they fell below the requirements for automatic admissions into their programs of choice were invited to the program as well as high performing students who attended low performing high schools. Attention was paid to recruiting underrepresented minority (URM) students to the Summer Bridge through visits to local schools, phone campaigns and a university-wide meet and greet event for prospective incoming minority freshmen called "Scarlet Night". Additionally, students who were admitted to a STEM college after a holistic review of their high school transcripts (with emphasis on their performance in math/science classes) rather than through the automatic admissions processes due to low SAT/ACT scores were also recruited for the Summer Bridge.

Nine-week summer bridge program

The summer bridge program typically lasts 9 weeks from 9 am to 3 pm, Monday through Friday. Students in the program were enrolled in an independent study workshop for which they received one credit as a means to ensure they participated fully in the program. Students received a stipend of approximately $3,000 to cover the cost of the course and fees and to help to make up for lost wages due to program participation. Some students used part of the stipend to assist with paying for on-campus housing while the majority commuted to campus.

In the first two weeks of the program, students covered pre-calculus in preparation for a deep dive into the course content for Calculus I. By the end of the summer, students had covered the content for Calculus I and Chemistry I up through the first exam in preparation for the fall semester. In addition, students had a choice between either Biology I or Physics I for their third subject area based on their majors. All courses were faculty led with faculty spending approximately 2–3 hours each day with the students in direct instruction. Courses were supplemented with SEP workshops. The workshops provided several hours each day of active learning and team-based problem-solving sessions. Workshops were led by high achieving SEP undergraduates acting as facilitators and peer content mentors. Peer content mentors rotated among the student groups to provide support. The program included specific lessons in study skills and time management as well as social activities.

Program characteristics

At the start of the Fall semester, Summer Bridge students became members of the Scholar Enrichment Program and were supported with additional scholarship aid; supplemental peer-led collaborative learning workshop courses in their freshmen large enrollment Calculus, Biology, Chemistry and Physics courses; and small collaborative learning groups led by peer mentors. They also have access to dedicated study space for the SEP which includes access to small conference rooms for team assignments and group study, a tutoring center and a computer lab. The Scholar Enrichment Program hosts career seminars led by alumni in STEM fields and hosts occasional social events to strengthen relationships between the students and the program leadership team. Summer Bridge students are recruited to serve as office aides, tutors, peer mentors and peer facilitators as they advance through their academic careers to keep participants engaged in the SEP community. These additional roles were funded through grant support and an institutional match. While the Summer Bridge is partly supported through ongoing grant funding, remaining funding for the Summer Bridge and the Scholar Enrichment Program comes from donor support and the institution's ongoing commitment to support the program.

Programs funded through the National Science Foundation Louis Stokes for Alliance Participation

Studies investigating STEM enrichment programs funded through the NSF-LSAMP alliance highlight the success of these programs at increasing both the diversity and success of students entering STEM fields (e.g. Bonsangue *et al.*, 2018; Ichinose and Bonsangue, 2016).

As part of the broader LSAMP alliance, the UH STEM enrichment program follows the objectives of the alliance that centralize on increasing both the quantity and quality of under-represented minority students entering and succeeding in STEM fields (Bonsangue *et al.*, 2018). In an NSF-LSAMP funded study investigating the role of professional development activities on the experiences and academic self-perceptions of black students enrolled in STEM fields, Bonsangue *et al.* (2018) under-scored the importance STEM enrichment program experiences in promoting the successful transition of students of color from their respective under-graduate and graduate degrees and into the STEM workforce. The study also emphasized the role of NSF-funding in creating meaningful opportunities for students of color to engage with programs that have a significant impact on increasing the diversity and completion rates of students in STEM fields of study (Bonsangue *et al.*, 2018).

Similarly, Hamilton and Parker (2010) evaluated the program impacts of students enrolled in the University of Maryland's NSF-LSAMP program. The program focuses on building supportive, motivating learning environments and includes key elements such as a summer bridge program, peer support networks, tutoring and advising (Hamilton and Parker, 2010). Since the inception of the program in 1994, the first semester GPA of students enrolled in the bridge program has almost doubled, and the retention rate from first to second year has remained above 90% (Hamilton and Parker, 2010). As a result of its collaborative approach to learning, the program has graduated over 1000 STEM undergraduates since its establishment in 1994, 70% of whom are under-represented minorities (Estrada *et al.*, 2016; Lee and Harmon, 2013).

Literature review

The early loss of STEM participants from science, math and technology programs has led to a series of efforts across the nation to address the issue of broadening diversity and increasing persistence of URM students within their respective fields of study. STEM intervention programs were designed to bridge the gap in educational attainment for under-represented minority students. These programs were built, in part, with the goal of increasing the quantity of successful URM students completing their undergraduate degrees in STEM fields, eventually increasing persistence and diversity of the STEM pipeline (Barlow and Villarejo, 2004; Maton *et al.*, 2000). Several research studies have identified examples of successful STEM intervention programs, as well as the key characteristics of programs that contribute to the increased persistence and retention of URM students in STEM fields (e.g. Chang *et al.*, 2014; Carpi *et al.*, 2017; Estrada *et al.*, 2016; Lane, 2016; Lee and Harmon, 2013; Jackson and Winfield, 2014; Tsui, 2007). Collective findings from these studies demonstrate that STEM enrichment programs that focus on an integrated, collaborative approach to student learning, implement peer support networks, faculty mentorship and research opportunities contribute to more successful student outcomes than URM students not participating in these programs.

Another important aspect of successful STEM intervention programs is their ability to build URM students' science identity through fostering social relationships and fostering science self-efficacy (Carlone and Johnson, 2007; Robnett *et al.*, 2015). Hurtado *et al.* (2010) found that STEM intervention programs focused on collaborative research experiences that positively contributed to the development of the science identity of URM students. Furthermore, their study found that peer networks and faculty mentorship played an integral role in empowering minority students and their identities.

Conceptual framework

Development of the UH Summer Bridge Program was guided by Treisman's (1992) Mathematics Workshop Model. Initiated at the University of Berkley, California, the Model is designed on identifying and building minority students' competencies in mathematics and science related courses through a collaborative and supportive peer network. Grounded on principles of academic integration and sense of belonging, Treisman's model addresses the tendency of URM students to be isolated from their classmates and rely on themselves to propel them through their academic journey (Treisman's, 1992). To tackle these issues, the Workshop Model operates under the premise that URM students can learn mathematics and science more efficiently and effectively through peer group learning, faculty mentorship, advising and supplementary support. Implementation of the Mathematics Workshop Model at Berkley has led to successful student outcomes among participants of the program, including increased student persistence in STEM fields and higher Mathematics grades. As a result of the well-documented success of Treisman's Mathematics Workshop Model, Treisman broadened the application of his model to include the full spectrum of STEM disciplines and applied collaborative learning techniques that could be incorporated in STEM intervention programs and workshops focusing on increasing the success of students of color in these fields (Bonsangue *et al.*, 2018; Drew, 2011). The principles of collaborative learning, peer mentorship and socio-academic integration that Treisman established as key to the success of students of color in STEM were used to implement and guide the University of Houston's Scholar Enrichment Program.

Several studies have examined the effectiveness of programs implementing Treisman's Mathematics Workshop Model (e.g. Chinn *et al.*, 2006; Duncan and Dick, 2000; Moreno and Muller, 1999). For example, Duncan and Dick (2000) investigated the Calculus success rates of students enrolled in the Math Excel Program, that at Oregon State University. Regression results demonstrated that after controlling for SAT Math scores, participation in the Math Excel program had a statistically significant positive effect on Math grades (Duncan and Dick, 2000). Also, Moreno and Muller's (1999) study examined the effects of the Emerging Scholar's Program (ESP) at the University of Texas at Austin on the mathematics grades of URM minority students enrolled in Calculus I courses. After controlling for key demographic variables including race, gender, ethnicity and SAT math scores, the resulting regression model indicated that students participating in the ESP program were 1.51 times more likely to earn one higher letter grade in Calculus I as compared to non-ESP students (Moreno and Muller, 1999).

Several studies (e.g. Fechheimer *et al.*, 2011; Eagan *et al.*, 2013; Wilson *et al.*, 2018) have demonstrated that undergraduate research opportunities early in students' college career have a positive impact on retention and graduation from STEM programs. These opportunities can be hard to come by for students at large enrollment institutions where the student population is far greater than the number of faculty. The combination of research experiences and peer-led supplemental learning communities is a powerful one but our work, along with that of many others (Duncan and Dick, 2000; Hamilton and Carter, 2010; Hurtado *et al.*, 2010) demonstrates that either element alone has a positive impact on student success in STEM fields.

Supported by prior studies surrounding variables that affect URM participation in STEM enrichment programs, the model describes variables used to create a control group of students with similar characteristics as the treatment group (students who participated in the enrichment program) using propensity score matching. These variables include age, prior academic performance, ethnicity, gender and socio-economic status. This study uses socio-demographic and pre-college variables that affect URM participation in STEM enrichment programs (Haeger and Fresqez, 2016). In addition, by controlling for academic performance prior to program participation, this study addresses criticisms of prior studies that did not effectively control for prior academic performance (Gonyea and Miller, 2011).

Methodology

Data source and sample

The study examined transcript records from three cohorts of students enrolled in the Scholar Enrichment Program Summer Bridge at the University of Houston, beginning with the Fall 2013 cohort until the Fall 2015 cohort ($N = 136$), as well as matched records of students not participating in the program ($N = 2{,}882$). These records contained information on students' course taking patterns, GPA, major, graduation as well as demographic and socio-economic data. The full sample of first time in college students used in the analysis was 3,018 students. Descriptive statistics for SEP students and the sample of Non-SEP students are presented in Table 1.

Variables

Two dependent variables were examined in this analysis. (1) Graduation within four years (Coded 1 as graduated and 0 for those who did not graduated). (2) Whether a student graduated in a STEM field of study (Coded 1 for students who graduated in their initial STEM field of study, and 0 for those who graduated in a non-STEM major). The independent variables selected in our analyses were guided by our conceptual framework, and prior literature surrounding factors contributing to the academic success of URM students in STEM fields (e.g. Carlone and Johnson, 2007; Chang *et al.*, 2014; Gilmer, 2007; Haeger and Fresquez, 2016; Hurtado *et al.*, 2010). These independent variables consisted of socio-

	SEP students (N = 136)		Non-SEP students (N = 2,882)	
Student Characteristics	N	%	N	%
Gender				
Female	60	44.12	1,180	40.94
Male	76	55.88	1,702	59.06
Race				
Asian	21	15.79	1,104	38.31
Black	42	31.58	246	8.54
Hispanic	59	44.03	826	28.66
Multi	0	0	89	3.09
Pacific Islander	0	0	4	0.14
Unknown	0	0	28	0.97
White	11	8.27	579	20.09
Age	17.94	M	17.99	M
	0.339	SD	0.588	SD
Academic Characteristics				
First-Term GPA	3.09	M	2.99	M
	0.872	SD	0.925	SD
Math SAT Scores	538.13	M	572.36	M
	130.90	SD	181.52	SD
Cumulative GPA	2.89	M	2.88	M
	0.811	SD	0.901	SD
Degree GPA	3.30	M	3.31	M
	0.410	SD	0.72	SD

Table 1. Descriptive statistics-full sample of SEP & Non-SEP students

demographic variables (age, gender, ethnicity), as well as academic factors, which included both pre-college experiences such as math SAT scores, as well as academic experiences at the University of Houston. These include Cumulative GPA, major, first semester GPA, grades in Calculus I, Chemistry I, and Biology I, degree GPA and total credit hours earned. Course letter grades were converted to GPA values using the University of Houston's grading system.

As students recruited into the summer bridge program are generally academically under-prepared for STEM college-level courses, evident through the lower math SAT scores of students entering these programs, controlling for math SAT scores as an integral part of the analysis that allowed for program participation effects between participants and non-participants of the program to be examined after accounting for these differences.

Data analysis

Data analysis was conducted in two phases. First, to account for the impact of selection bias, the study utilized propensity score matching techniques to match students with similar characteristics on a selection of baseline covariates. Analytically, Haeger and Fresquez's (2016) Conceptual model for propensity score matching also guided the study to assess the impact of program participation on GPA and graduation rates. In their study, the authors describe the importance of undergraduate research experience and STEM enrichment programs can have particularly on academically under-prepared, low-income URM students. They also underscore the benefits that participation in such programs could have in terms of compensating for the certain disadvantages that these students could undergo .Guided by the analytical framework posed by Haeger and Fresquez (2016) this study controlled for prior academic performance, as well as socio-demographic variables such as race and gender, to create a sample of program participants and non-participants that was matched on a series of baseline characteristics which otherwise could bias program participation effects. The use of propensity score matching strengthened the results of our study by enabling students enrolled in the Scholar Enrichment Program to be matched with non-participants of the program that had similar characteristics, allowing an accurate comparison to be made between participants and non-participants of the program. The value of propensity score matching as a tool that eliminates bias caused by confounding variables and increases the robustness and accuracy of statistical models is well-documented in the literature (e.g. Guo and Fraser, 2015; Rosenbaum and Ruben, 1983). Guided by prior research that highlights the importance of pre-college factors on the success of URM students in STEM fields (e.g. Duncan and Dick, 2000; Moreno and Muller, 1999) and primarily following the variables chosen by Haeger and Frasquez's (2016) model the baseline covariates selected for analysis included age, gender, race, SAT math scores and major. The first step of propensity score analysis involved the use of a logistic regression model that assessed the probability that a student will participate in the treatment, or the Scholar Enrichment Program Bridge (Caliendo and Kopeinig, 2008; Guo and Fraser, 2015; Rosenbaum and Ruben, 1983). In this way, the study used a counterfactual framework to estimate that the probability of a participant's selection in a group matched SEP Bridge students with traditional STEM students (Guo and Fraser, 2015; Shadish *et al.*, 2002).

The user created program *pscore* on STATA v.16 was used to generate the propensity scores, as well as the region of common support to determine if there are a sufficient number of cases to match students in the treatment group (Guo and Fraser, 2015; Melguizo *et al.*, 2011). The use of pscore in estimating the propensity score based on baseline characteristics has been well-documented in evaluation research concerning the application and procedures involved in propensity score matching techniques (e.g. Becker and Inchino, 2002; Bia and Mattei, 2017). Next, the STATA program *psmatch2* was used to create a matched sample of students using a 1:1 neighbor matching method within a pre-specified caliper .The restriction of a caliper was used to overcome the errors involved with matching with propensity scores that are too far apart and was computed as a quarter of the SD of the estimated propensity scores of the sample (Rosenbaum and Rubin, 1983). Following *psmatch2,* the program *pstest* was used to test the differences between covariate means both prior and after the matching process and displays the reduction in bias across the covariates that occurred as a result of matching.

Following the estimation of propensity scores, the nearest neighbor 1:1 matching method within caliper resulted in a matched sample of 131 treatment cases (SEP Bridge students) and an equal sample of 131 control cases (Non-SEP Bridge students). The implementation of the nearest 1:1 matching method restricted the resulting sample to an exact number of non-SEP Bridge students who matched the baseline characteristics of SEP students.

After matching, a logistic regression model was used to estimate whether students in the SEP Bridge program were more likely to graduate, relative to non-SEP Bridge students, after controlling for baseline covariates. A second logistic regression model was conducted to estimate whether students in the SEP Bridge program were more likely to be retained in a STEM field, relative to non-SEP Bridge students, after matching on baseline covariates. Odds ratios and 95% corresponding confidence intervals demonstrate the analytical results for both models.

The matched data sample was used to conduct independent sample t-tests to examine the significance in the differences between the grades of students in the large freshman enrollment classes of Calculus I, Chemistry I and Biology I, and subsequently, these results were disaggregated by race. T-values and corresponding p-values are presented. All analyses were conducted using STATA V.16 and SPSS v.24.

Limitations

Although this study covers data from three enrolled SEP Bridge cohorts, it was still limited to data from a single institution. However, this institution does represent one the largest Hispanic Serving Institutions in the state of Texas and one of the top 15 most diverse campuses in the nation (US News and World Report, 2021). In addition, data used in this analysis focused on tangible student variables such as GPA, graduation rates and socio-demographic variables. Matching on variables such as in-class engagement and career aspirations was not possible as these data were not available. In addition, studies highlight the importance of student motivation to persist in their STEM degree plan as a major factor influencing student performance, persistence and graduation rates (Bonsangue *et al.*, 2018; Jackson and Winfield, 2014). Although the UH summer bridge program focuses on learning experiences and intervention techniques that increase under-represented students' academic self-efficacy and sense of motivation to persist through their respective STEM fields of study, the collection of specific qualitative data that measures the motivation of students enrolled in the program could not be collected, which inevitability limits the findings provided by this study.

Results

Results of the analysis are organized into two main sections. First, a description of the propensity score analysis results, as well as the reduction in bias across baseline covariates across pre-matched and post-matched samples, is presented. Then, the propensity score adjusted findings are presented according to our listed research questions.

Table 2 details the covariate balances before and after matching using 1:1 nearest neighbor with caliper. Findings indicate that after matching, no significant differences were found between the first semester GPA, final cumulative GPA and total credit hours of students in the treatment and control groups.

Table 3 shows results of independent sample *t*-tests disaggregating course completion and GPA outcomes by race. Findings indicated that after matching on socio-demographic and pre-college variables, Hispanic Summer Bridge students had significantly higher first semester GPA and final cumulative GPA compared to non-Summer Bridge Hispanic students ($p < 0.05$), while differences between African-American Summer Bridge and non-Summer Bridge students' GPAs were not significant. In addition, GPA averages among Hispanic students were higher than those of African-American students.

RQ1. Relative to their non-participating peers, to what extent does participation in the University of Houston's Scholar Enrichment Program Summer Bridge have an association with degree completion and retention in a STEM field?

Variable	Pre-matched sample: Mean treatment (SEP)	Mean control (Non-SEP)	$p>\|t\|$	1:1 NN with callipers sample: Mean treatment (SEP)	Mean control (Non-SEP)	$p>\|t\|$	% Reduction in Bias
First Semester GPA	3.09	2.99	0.213	3.09	2.90	0.06	−108%
Final Cumulative GPA	2.89	2.88	0.856	2.88	2.69	0.07	−15.4%
Total Credit Hours	117.02	122.6	0.155	117.02	114.47	0.696	54.2%

Table 2. Covariate balances across treatment (SEP) and control (Non-SEP) students before and after matching

Descriptive statistics

Both treatment and control groups were majority URM, with 75.2% URM students in the treatment group and 73% of those in the control (non-Summer Bridge group). After matching, graduation rates of students in treatment and control groups were similar (56% of SEP Bridge and non-SEP Bridge students). Likewise, in terms of retention in STEM, similar percentages of SEP Bridge and non-SEP Bridge students were retained in a STEM field of study (50.4% of non-SEP Bridge students and 50% of SEP Bridge students).

Disaggregating by race, Hispanic students had higher graduation and retention rates compared to African-American students. For Hispanic students, 61.4% of SEP Bridge students graduated within 4 years, compared to 55.2% of non-SEP Bridge students. 51% of Hispanic SEP Bridge students were retained in STEM, compared to 45% of Hispanic non-SEP Bridge students. African-American students in SEP Bridge and non-SEP Bridge groups had similar graduation rates (49% treatment, 51% control).

44% of black SEP Bridge students were retained in STEM, compared to 51% of non-SEP Bridge black students. Chi-square tests of independence were conducted to test the significance of differences between group proportions. Results indicated that there were no significant differences between SEP Bridge and non-SEP Bridge students in graduation and retention rates after matching ($p > 0.05$). Given the fact that the majority of students enrolled in the SEP bridge program were black and Hispanic students, the percentage of White and Asian students was very small, rendering it not possible to conduct chi-square tests of independence and examine program effects for students from these backgrounds.

Probability of graduation for matched group of students

Results of the logistic regression analysis conducted on the nearest neighbor matched group of SEP Bridge and non-SEP Bridge students are presented in Table 4. The outcome variable of interest was dichotomous, and measured whether a student graduated within 4 years of entering the program as a function of their predicted propensity scores, program participation (SEP Bridge vs non-SEP Bridge), as well as the academic variables of cumulative GPA and total credit hours earned. The Nagelkerke R^2 demonstrated that 68.2% of the variance in the student's probability of graduation was accounted for by the variables in the model. In addition, the model correctly predicted the probability of graduation for 87.5% of the 262 cases.

For the matched group of SEP Bridge and non-SEP Bridge students, participation in the Scholar Enrichment Summer Bridge program was a statistically significant predictor of graduation ($p < 0.05$). Our findings indicate that SEP Bridge students are 3.46 times more likely to complete their degree in a STEM field compared to their non-SEP Bridge peers, after controlling for baseline covariates. Cumulative GPA and accumulated credit hours were statistically significant predictors of graduation, as students with higher cumulative GPAs were 4.8 times more likely to graduate than those with lower GPAs ($p < 0.005$), and students

Table 3. Independent Samples *t*-test: GPA Outcomes across Hispanic and African-American SEP & Non-SEP Students

Variable	Group (black)	*N*	*M*	SD	*t*	Group (Hispanic)	*N*	*M*	SD	*t*
Cumulative GPA	SEP	40	2.71	0.83	−1.20	SEP	56	2.99	0.91	−1.75*
	Non-SEP	43	2.47	1.06		Non-SEP	58	2.71	0.81	
First Semester GPA	SEP	40	2.81	0.97	−0.60	SEP	56	3.21	0.83	−1.78*
	Non-SEP	43	2.67	1.15		Non-SEP	58	2.93	0.84	

Note(s): $*p < 0.5$
$*p < 0.005$

Variables	Matched students (n = 238) Exp (B)	95% CI for Exp (B)	
Estimated Propensity Scores	331.69	0.42	260545.01
Program Participation (SEP[1])	3.46**	1.45	8.26
Cumulative GPA	4.80**	1.82	12.64
Accumulated Credit Hours	1.05**	1.03	1.07
Model Summary			
N		262	
% of cases predicted correctly		87.5	
Nagelkerke R^2		0.682	
−2 Log likelihood (df)		153.44	

Note(s): [1]: Reference category
*$p < 0.5$
*$p < 0.005$

Table 4. Logistic regression results: SEP program participation effects on graduation (matched sample)

with higher accumulated credit hours were 1.05 times more likely to graduate than students with lower accumulated credit hours.

Probability of retention in a STEM field for matched group of students

Table 5 details the results of the logistic regression estimating the probability of student retention in a STEM field of study. Findings indicate that the model accurately predicted the retention of 80.9% of students in the matched sample of students used in the analysis. The Nagelkerke R^2 showed that 57.7% of the variance in STEM retention was captured by the variables used in our model.

After matching students on baseline covariates, findings indicate that participating in the SEP Bridge program was also a statistically significant indicator of STEM retention for students in our sample. Participants of the SEP Bridge program were 2.55 times more likely to be retained in their initial STEM field of study compared to their non-SEP Bridge peers ($p < 0.05$). Total credit hours accumulated was also significantly associated with retention in a STEM field, increasing students' odds for being retained by 1.05 times as compared to students with less accumulated credit hours ($p < 0.005$

Variables	Matched students (n = 262) Exp (B)	95% CI for Exp (B)	
Estimated Propensity Scores	88.43	0.31	25,429.35
Program Participation (SEP[1])	2.55*	1.23	5.29
Cumulative GPA	2.05	0.92	4.59
Accumulated Credit Hours	1.05**	1.03	1.06
Model Summary			
N		262	
% of cases predicted correctly		80.8%	
Nagelkerke R^2		0.577	
−2 Log likelihood (df)		195.21	

Note(s): [1]Reference category
*$p < 0.5$
*$p < 0.005$

Table 5. Logistic regression results: SEP program participation effects on retention in STEM field (Matched Sample)

RQ2. Relative to their non-participating peers, to what extent does participation in the UH Scholar Enrichment Program Summer Bridge have an association with successful course completion rates in the large enrollment freshman STEM classes of Calculus 1, Chemistry 1 and Biology 1?

Table 6 presents the results of the independent samples *t*-tests comparing the course grades of students enrolled in Calculus I, Chemistry I and Biology I after matching. Results indicate that after matching, students enrolled in the SEP Bridge program have significantly higher course grades in Chemistry I and Biology I freshman courses compared to their non-SEP Bridge peers. In Chemistry I, SEP Bridge students earned an average GPA of 2.85, compared to an average of 2.15 earned by students not enrolled in the program ($p < 0.05$). In Biology I, SEP Bridge students earned an average of 2.99, compared to 2.61 earned by non-SEP Bridge students ($p < 0.05$). No significant differences were found between the Calculus grades of SEP Bridge and non-SEP Bridge students after matching.

Table 7 presents course grade comparisons between African-American and Hispanic SEP Bridge and non-SEP Bridge students. Results indicate that Hispanic SEP Bridge students again scored higher average Calculus, Chemistry and Biology grades compared to their African-American peers. In addition, results show that Hispanic SEP Bridge students scored significantly higher grades in Chemistry I courses compared to non-SEP Bridge Hispanic students.

Pell-eligible student outcomes

To compare the academic success and course completion outcomes of Pell-eligible students enrolled in the SEP Bridge, a separate propensity score match analysis was conducted using Pell-eligible SEP Bridge students ($n = 64$), and a sample of non-SEP Bridge Pell-eligible

Table 6. Independent Samples *t*-test Comparing Calculus, Chemistry and Biology Grades across Matched SEP and non-SEP students

Subject	Group	*N*	*M*	SD	*t*	*p*
Calculus I	SEP	106	3.34	1.18	−1.3	0.099
	Non-SEP	61	3.10	1.14		
Chemistry I	SEP	64	2.85	0.99	−3.1	0.001**
	Non-SEP	49	2.15	1.37		
Biology I	SEP	47	2.98	1.09	−1.82	0.04*
	Non-SEP	57	2.61	1.02		

Note(s): *$p < 0.5$
*$p < 0.005$

Table 7. Course grade comparisons across African-American and Hispanic SEP & Non-SEP students

Variable	Group (Black)	*N*	*M*	SD	*t*	Group (Hispanic)	*N*	*M*	SD	*t*
Calculus I	SEP	35	3.0	1.33	−0.77	SEP	50	3.46	1.11	−1.18
Grade	Non-SEP	20	2.70	1.49		Non-SEP	22	3.14	0.99	
Chemistry I	SEP	18	2.44	0.87	−2.07	SEP	27	2.94	1.23	−2.89**
Grade	Non-SEP	14	1.55	1.55		Non-SEP	19	1.94	1.10	
Biology I Grade	SEP	18	2.78	1.29	−1.03	SEP	18	2.86	1.06	0.15
	Non-SEP	21	2.39	1.10		Non-SEP	21	2.90	0.85	

Note(s): *$p < 0.5$
*$p < 0.005$

students enrolled in STEM fields (n = 1,205). Using the same control variables and matching method for the full sample, the resulting match contained an equal number of Pell-eligible SEP Bridge and non-SEP Bridge students (n = 64). Independent sample t-tests were conducted to test the significance of differences between treatment and control groups in terms of first term GPA, final cumulative GPA and course grades in freshman Calculus I, Biology I and Chemistry I.

Results are presented in Table 8. Findings indicate that Pell-eligible SEP Bridge students earned a significantly higher first semester GPA, and final cumulative GPA, compared to their non-SEP Bridge counterparts. In addition, SEP Bridge Pell-eligible students had significantly higher course grades in all three freshman courses of Calculus I, Biology I and Chemistry I ($p < 0.05$).

Table 9 presents the course grades, as well as first semester and cumulative GPA outcomes of Pell-eligible students broken down by race. Findings indicate that Hispanic Pell-eligible students enrolled in the SEP bridge program earned significantly higher grades in Calculus I, and Chemistry I, as well as higher first semester GPA compared to Hispanic students not participating in the summer bridge program ($p < 0.05$). No significant differences were found between participants and non-participants of the SEP bridge program across Pell-eligible black students.

Subject	Group	N	M	SD	t	p
First Semester GPA	SEP	64	3.04	0.83	−1.76	0.04*
	Non-SEP	64	2.76	0.96		
Cumulative GPA	SEP	64	2.83	0.76	−1.74	0.04*
	Non-SEP	64	2.54	1.07		
Calculus I	SEP	49	3.37	1.09	−1.94	0.03*
	Non-SEP	26	2.81	1.36		
Biology I	SEP	24	3.05	0.83	−1.85	0.03*
	Non-SEP	28	2.55	1.06		
Chemistry I	SEP	33	2.85	0.88	−2.56	0.006**
	Non-SEP	16	2.06	1.23		

Note(s): *$p < 0.5$
*$p < 0.005$

Table 8.
Independent samples t-test comparing academic and course outcomes across matched SEP and non- SEP Pell-eligible students

Variable	Group (Black)	N	M	SD	t	Group (Hispanic)	N	M	SD	t
Calculus I Grade	SEP	27	3.15	1.34	−0.69	SEP	38	3.60	0.86	−1.86*
	Non-SEP	13	2.85	1.26		Non-SEP	15	3.07	1.16	
Chemistry I Grade	SEP	14	3.13	0.89	1.38	SEP	19	2.81	1.19	−0.88*
	Non-SEP	5	2.53	1.55		Non-SEP	11	2.41	1.14	
Biology I Grade	SEP	12	2.67	1.14	−0.60	SEP	13	2.93	0.68	0.92
	Non-SEP	15	2.93	1.10		Non-SEP	12	3.20	0.78	
Cumulative GPA	SEP	32	2.73	0.86	−0.60	SEP	41	3.01	0.96	−1.49
	Non-SEP	32	2.69	0.78	−0.22	Non-SEP	41	2.74	0.69	
First Semester GPA	SEP	31	2.90	0.92	−0.11	SEP	41	3.30	0.62	−2.16*
	Non-SEP	32	2.87	0.98		Non-SEP	41	2.89	1.03	

Note(s): *$p < 0.5$
*$p < 0.005$

Table 9.
Program participation effects for Pell-eligible students: By race

Discussion

Findings from this study demonstrate that participation in the Scholar Enrichment Program Summer Bridge does, in fact, lead to positive student outcomes after controlling for key socio-demographic and pre-college factors. In particular, our analysis indicated that after controlling for estimated propensity scores, SEP Bridge students were more likely to graduate within 4 years at higher rates compared to their non-SEP Bridge peers and were more likely to be retained in their initial STEM field of study. Finally, our results demonstrated that after matching, SEP Bridge students had significantly higher grades in Chemistry I, and Biology I when compared to non-SEP Bridge students.

These findings highlight the positive effect that STEM enrichment programs can have on URM student persistence, degree completion and educational outcomes. Specifically, findings highlight the influence of the UH summer bridge program on increasing the academic competency of URM students prior to entering their freshman year of college during the 9-week summer bridge program, demonstrated through the higher first semester GPA of SEP Bridge students compared to non-SEP Bridge students. These findings are supported by prior studies that found a significant improvement in first year GPA and successful transition into the freshman year of college as following participation in a summer bridge program (e.g. Ackermann, 1991; Ashley *et al.*, 2017; Raines, 2012). In addition, results indicated that participation in the SEP Bridge increased freshman Calculus I grades by 8%, Chemistry I grades by 33% and Biology I grades by 14%. These findings are also supported by prior studies that found performance gains in STEM courses for students enrolled in STEM enrichment programs (e.g. Duncan and Dick, 2000; Moreno and Muller, 1999; Russomanno *et al.*, 2010).

Several characteristics of the UH Summer Bridge Program contribute to its success in promoting higher graduation rates and course grades in freshman STEM courses. To begin with, the 9-week summer program offers URM students' intensive instruction, support and tutoring in STEM courses that may improve inadequacies in academic preparation (Brown and Campbell, 2009; Chang *et al.*, 2014). Additionally, the collaborative, peer-focused learning environment that the Summer Bridge Program is founded upon could also have a positive effect in improving the science identity, academic integration and sense of belonging of URM students, leading to successful academic outcomes among participants of these programs (Duncan and Dick, 2000; Slovacek *et al.*, 2012; Treisman, 1992). Given that the sample size investigated in this study was limited to students attending the UH Scholar Enrichment Program, the ability to make inferences regarding program effects on under-represented student populations was limited. For this reason, expanded research studies are encouraged that investigate program effects on a larger student population, including students enrolled in participating institutions funded through NSF-LSAMP, that enable a broader analysis of program participation effects to be conducted. Such future analyses will lend a clearer representation of intervention effects across several institutions and student bodies.

Findings from this study indicate that SEP program participation has a stronger impact on Pell-eligible students in terms of academic success and course completion outcomes. The financial assistance offered by the program, coupled with the faculty support and mentorship provided to URM students, alleviates the stress of many URM students having to simultaneously support themselves and succeed academically through college (Hurtado *et al.*, 2010).

In terms of disparities in educational achievement, results did indicate disparities in program participation effects between African-American and Hispanic SEP students. SEP participation had a significant effect on the final cumulative GPA and first-year GPA of Hispanic students across the general sample and Pell-eligible students, but program participation did not have the same effect on African-American SEP students. These results support previous studies that highlight the more significant disparities present among Black students (e.g. Riegle-Crumb, 2019; Estrada *et al.*, 2016). In addition, given that the University of Houston is a Hispanic Serving Institution (HSI), Hispanic students may feel a greater sense of belonging due to the presence of a large Hispanic community, supporting prior studies that demonstrate the importance of Hispanic Serving Institutions in creating successful and equitable student outcomes for Hispanic students in STEM fields (Crip *et al.*, 2009; Garcia and Dwyer, 2018). Also, these results could be associated with prior literature that links the support and faculty mentorship received through intervention programs with greater academic gains for Hispanic students in particular (Cole and Espinoza, 2008; Torres and Solberg, 2001).

Implications for future research

The influence of race on persistence and graduation in a STEM major is related to unequal academic preparation and barriers to educational opportunities (Chang *et al.*, 2014; Lane, 2016; Moreno and Muller, 1999; Crisp *et al.*, 2009). Findings from this study demonstrate that after controlling for pre-college academic ability and socio-demographic characteristics, participation in a STEM intervention program could significantly increase URM graduation rates, but leaves more research to be addressed in terms of the STEM retention rates of URM students. Given these results, our findings call for enhanced program building and research that addresses specific points in time whereby minority students are more likely to require additional support, and tailor program components in order to significantly improve the educational attainment of black students in particular, and URM students enrolled in SEP-like programs as a whole. Moreover, as suggested by fellow researchers, further research is needed to disentangle the complex array of factors that impact URM student persistence and success in STEM fields, particularly in the intertwined areas of socioeconomic impacts and cultural capital which influence student choices and behaviors (Walpole, 2003).

While the results of this study suggest a positive impact of intervention programs on certain measures of student success, current research has suggested the need to explore student success and the factors contributing to it in a more holistic manner. For instance, Garibay (2018) examined the extent to which STEM undergraduate experiences and institutional contexts collectively contributed to the development of democratic educational outcomes among graduates. These outcomes include social agency and producing research that will ultimately benefit underserved communities (Garibay, 2018). Such a transformative approach to student success transcends traditional measures of degree attainment and focuses on the significance of using STEM education to improve the lives of marginalized students and create a more just, equitable society (Baillie *et al.*, 2011; Letizia, 2016). To that end, while this study examines intervention program effects on traditional measures of student success, it is equally important that future research in this space expands traditional notions of academic achievement that encompass social justice and equity. To achieve this, collecting qualitative data through the use of questionnaires would be a valuable data source that could offer a plethora of information regarding students' attitudes, perceptions and motivations as it comes to their academic success in STEM.

Developments in the manner through which student success is defined, specifically for under-represented student populations, allow for a more nuanced perspective of academic achievement to be cultivated that is more reflective of the unique experiences of this specific student population. Specifically, subsequent work might consider broader indicators of success (e.g. sense of belonging, engagement and science identity for URM populations). Future qualitative work might also usefully include student voices and experiences. Finally, additional work is needed to assess the degree to which bridge programs articulate with supplemental instruction programs in terms of improving success in degree required courses (e.g. calculus).

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