STEM Graduation Outcomes of the Rice University Emerging Scholars STEM Intervention and Summer Bridge Program

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Abstract

STEM graduation rates, cumulative GPAs, and final GPA distributions of years 2016 to 2019 graduates were evaluated for students who participated in Rice University's STEM intervention (the Rice Emerging Scholars Program, or RESP, which is partly funded through an NSF S-STEM grant), which begins with a pre-freshman STEM summer bridge program. RESP participants (n=89) and a comparison category of students (n=81) were identified as being underprepared for STEM coursework. Outcomes from the rest of the graduating classes were also assessed (i.e., non-comparison, non-RESP students). Incoming high school AP and IB credits were a moderate predictor of cumulative graduation GPA. After controlling for test credits, student status predicted cumulative graduation GPA, with higher GPAs in the non-comparison, non-RESP condition. Seventy-two RESP students graduated with a STEM major (81% STEM retention) compared with 62% of comparison students and 87% of non-comparison, non-RESP students. A chi-square test found a significant difference in favor of higher STEM retention among RESP students than the comparison students. Of RESP STEM graduates, 94% graduated with at least a B- GPA, compared with 86% of the comparison students, and 97% of the non-comparison, non-RESP students. A chi-square test approached significance in favor of more B- and above GPAs among RESP students than the comparison students. Overall, we found that high school preparation predicted STEM students' graduation GPAs. Further, although RESP participation did not predict the cumulative GPAs of STEM majors, the program may: 1) improve STEM degree persistence and 2) ensure that more of the program's STEM graduates achieve at least a B- cumulative graduation GPA. The number of RESP and comparison students is relatively small, yet these findings nevertheless offer preliminary evidence that the intervention may be effective at improving STEM outcomes for students who would otherwise struggle the most with their coursework. As more students graduate from the university, we will be able to make stronger conclusions about the effectiveness of RESP in improving outcomes of underprepared STEM students.

Introduction

College STEM interventions are designed to increase the success of STEM students in college and improve class performance and retention as a STEM major [1]. Many interventions provide institutional support proactively, rather than requiring students to seek out help once they are already struggling [2]. Interventions also increase students' sense that they belong in their major, as well as their social support from other participants in the intervention [3]. Intervening early in students' college careers can be particularly impactful, as students' first year, and to a lesser extent their second year, is when they make crucial academic decisions, including their choice of major [4].

STEM bridge programs are a type of early (pre-college) STEM intervention. They are residential programs that take place the summer before matriculating STEM students begin college and are designed for students who have been identified as relatively underprepared for STEM

coursework, often female and/or underrepresented minority students in particular [5]. A primary goal of STEM bridge programs is to increase the number of students who have access to a strong STEM foundation by increasing students' STEM knowledge and exposure to STEM content [6]. Bridge programs also provide more general college preparation through increasing campus familiarity and offering study skills instruction [7].

Although the overall objectives of STEM bridge programs are relatively consistent across colleges and universities, a persistent concern in this line of research is the lack of clarity surrounding each program's characteristics, research design, and analysis of outcomes. This heterogeneity renders generalizable conclusions across programs difficult [8]. We attempt to counter that concern with a clear review of the selection criteria, process, and analysis of outcomes of Rice University's STEM intervention, which comprises a summer bridge program as one of its two primary elements.

The Rice Emerging Scholars Program

Rice University's STEM intervention, or RESP (the Rice Emerging Scholars Program), aims to ensure equal STEM outcomes for all admitted STEM students, regardless of high school background. RESP operates under the belief that all students admitted as scientists and engineers to Rice University have the potential to be successful STEM graduates. However, matriculating students enter with varying and unequal access to educational and economic opportunities, meaning that some students enter at a relative academic disadvantage compared to peers who attended more rigorous high schools.

The program's goal is for all participants to persist, thrive, and graduate in the degree plan of their choice. Comprehensive in nature, RESP supports participants in two distinct phases: the pre-matriculation bridge intervention, and post-matriculation ongoing support.

Participant Selection and Admission

Participant selection occurs after students have been admitted to Rice University. Participants are identified based on their STEM diagnostic exam scores, math SAT/ACT scores, and STEM SAT subject test scores. Selection is race blind. Priority is given to students who are first in their families to attend college and/or who attended an under-resourced high school. Students are individually recruited for participation in RESP through personalized phone calls with program staff.

Curriculum and Experience

The summer portion of RESP is six weeks long and takes place during the summer before students matriculate at Rice. The program is anti-remedial, focusing instead on the most challenging topics covered in freshman year calculus, chemistry, and physics. Participation is free for all students and covers tuition, room and board, activity fees, and travel expenses for the duration of the summer.

Participants attend class on weekday mornings and spend weekday afternoons in guided groupwork facilitated by upperclassmen (many of whom are former RESP participants

themselves). The groupwork covers both challenging concepts and the learning strategies needed to succeed in rigorous coursework. Participants choose a "track," or area of focus during the program by selecting a computer science coding project, natural science research, or an engineering design curriculum. Students' coursework corresponds to their track, including a substantial required final project. In the evening, students complete homework, attend tutoring sessions, and participate in activities designed to ease their transition to college, all facilitated by the same upperclassmen tutors. During the weekends, students enjoy free time, complete their homework, prepare for exams, and attend field trips designed to increase their familiarity with Houston.

Post-Summer Student Support

Starting in the summer and continuing through freshman year (and until graduation, if the student desires), RESP students meet individually with one of two program staff members, who provide an "intrusive" or "proactive" model of advising. Participants choose one staff member as their primary advisor and meet with that advisor during the summer, weekly or bi-weekly throughout their freshman year, and as needed after their first year. The goal of these meetings is to proactively address any barriers to successful STEM completion or university graduation, including and beyond academic concerns (e.g. financial or social concerns).

RESP participants receive other support throughout their time at Rice University. First, the program pays for peer tutors. Second, it addresses the financial concerns of students with demonstrated financial need by purchasing necessary textbooks or miscellaneous supplies. Third, the program offers a "second summer," of structured support during the summer after students' freshman years. During this second summer, program participants can either complete coursework (to make a rigid STEM degree plan more manageable by taking multiple classes or to focus on one particularly difficult course) or conduct paid STEM research. RESP pays for on-campus housing and meal costs for all second summer participants, as well as any portion of summer school tuition not covered by Rice's summer scholarship program.

Current Study

For this study, STEM was defined as the physical sciences, biological sciences excluding kinesiology (excluded because this major has fewer core STEM course requirements than all other STEM majors), math, and engineering. The RESP program has two primary goals: 1) graduate more students as STEM majors, and 2) graduate more STEM students with B- or higher (2.67 cumulative GPA) GPAs. Therefore, we examined both retention and cumulative GPA as outcomes.

Correspondingly, we developed the following hypotheses. First, based on the evidence of the importance of high school STEM coursework, particularly at the advanced AP level, on college STEM performance [9], we expected greater high school STEM credits to predict higher STEM GPAs in college, irrespective of student status (i.e. RESP, comparison, or non-comparison, non-RESP students).

Hypothesis 1: High school STEM AP/IB credits will positively predict final cumulative GPA.

Next, we explored cumulative graduation GPAs, only including students who graduated with a STEM major.

Hypothesis 2: RESP students who graduate in STEM will have higher cumulative GPAs than comparison students who graduate in STEM.

Next, we expected RESP to produce more students graduating in STEM majors than the comparison students.

Hypothesis 3: RESP students will be retained as STEM majors at a higher rate than the comparison students.

Finally, another goal of program administrators is to bring the performance of RESP participants to at least a B- average, understanding that many of these students cannot realistically make up for many years of less rigorous school coursework to receive A's in difficult college coursework at a competitive university.

Hypothesis 4: A greater proportion of RESP students who graduate in STEM will have 2.67 or above GPAs than comparison students who graduate in STEM.

Ultimately, our goal is to determine whether RESP is meeting its primary objectives of graduating more and higher performing STEM majors than comparable underprepared STEM students.

Methods

Participants

RESP participants (n=89) and comparison students (n=81) were STEM matriculating students identified as being underprepared for STEM coursework. To provide a reference group, we also analyzed data from all non-comparison, non-RESP students who matriculated as STEM majors (n=2,384), and whom the university had deemed to be adequately prepared for STEM coursework. All students graduated between 2016 and 2019.

Measures

We used final cumulative GPA (which consists of both STEM and non-STEM classes) as our GPA outcome. Test credits were the number of test credits transferred to the university (only 4 and 5 AP exam scores qualified; IB credits and A Levels were also accepted) in STEM courses, which included the physical and natural sciences, statistics and calculus, and computer science exams. Unsurprisingly, students had fewer AP and IB STEM credits on average in the RESP (M=14.18) and comparison (M=14.34) categories than the rest of the matriculating class (M=26.24). For STEM retention, a student was considered "retained" if he or she graduated with at least one STEM major (we counted double majoring in a non-STEM major as STEM retention), excluding kinesiology.

Statistical Procedures

We used multiple linear regression and chi-square tests in our analyses. Apart from exploring STEM retention rates, we conducted all cumulative GPA analyses only on students who graduated as STEM majors, meaning we excluded STEM leavers from these analyses.

Results

First, we examined whether high school credits predicted cumulative GPA. Supporting Hypothesis 1, incoming test credits were a moderate (β=.323, p=.002) predictor of cumulative graduation GPA.

We then controlled for incoming test credits to explore the link between student category and cumulative GPA to test Hypothesis 2. Student category predicted cumulative graduation GPA, accounting for 10% additional variance (p=.031) with higher GPAs for non-comparison, non-RESP students. There was no significant difference between the RESP and control students on cumulative GPA in this model, thus Hypothesis 2 was not supported. The unadjusted GPAs are listed in Table 1 below.

Table 1

Final Cumulative GPAs of Students Graduating with STEM Degree

Student Status	**n**	**Mean**	**Std. Dev**
Comparison Students	50	3.300	0.451
All Other Students	1,777	3.603	0.366
RESP Students	71	3.233	0.388
Total	**2,372**	**3.572**	**0.388**

To explore Hypothesis 3, we used a chi-square test to determine differences in graduation retention rates by student category. Of RESP students (n=89), 71 students graduated with a STEM major (80% STEM retention). Of the comparison students (n=81), 50 graduated as a STEM major (62% STEM retention). Of the rest of the university students entering as STEM majors (n=2,202), 81% (n=1,777) graduated as a STEM major.

To determine comparison student versus RESP student differences in STEM retention rates, we conducted a chi-square test, which found a significant difference ($\chi^2(170) = 6.73$, p=.009) between retention percentages in favor of higher STEM retention for RESP students. See Figure 1 below.

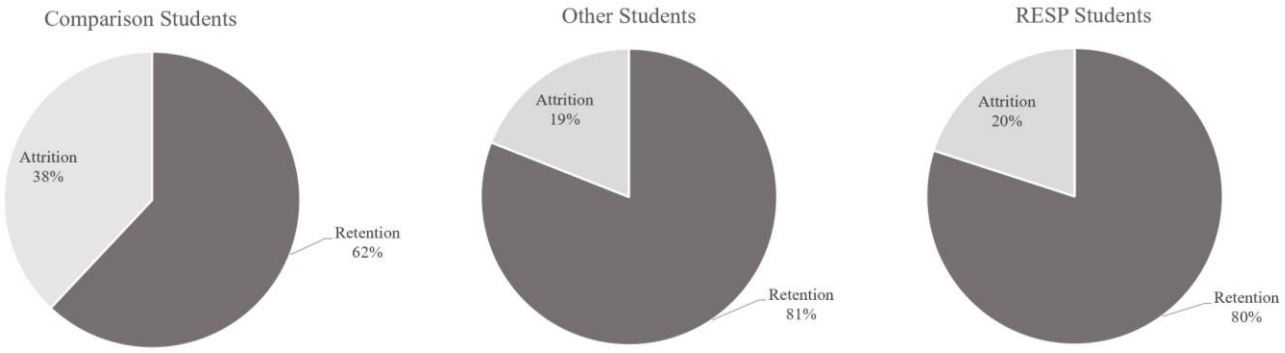

Figure 1. STEM graduation and attrition rates by student category

Finally, Hypothesis 4 explored the proportion of students who graduated with a B- (2.67) cumulative GPA or higher in a STEM major. Chi-square analyses compare observed frequencies of a variable against expected frequencies, with the null hypothesis being that there are no differences in frequencies between any of the three types of students. Examining the proportion of B- and higher students, 67 out of 71 RESP participants who graduated in STEM had at least a B- GPA (94%). Of the comparison students, 43 out of 50 did (86%), and of the rest of the university, 98% (1,736 out of 1,777) did. The difference between RESP and comparison students was marginally significant ($\chi^2(121) = 2.485$, p=.115) in favor of a higher proportion of B- and higher GPAs for RESP students; however, we were unable to reject the null hypothesis. See Figure 2 below.

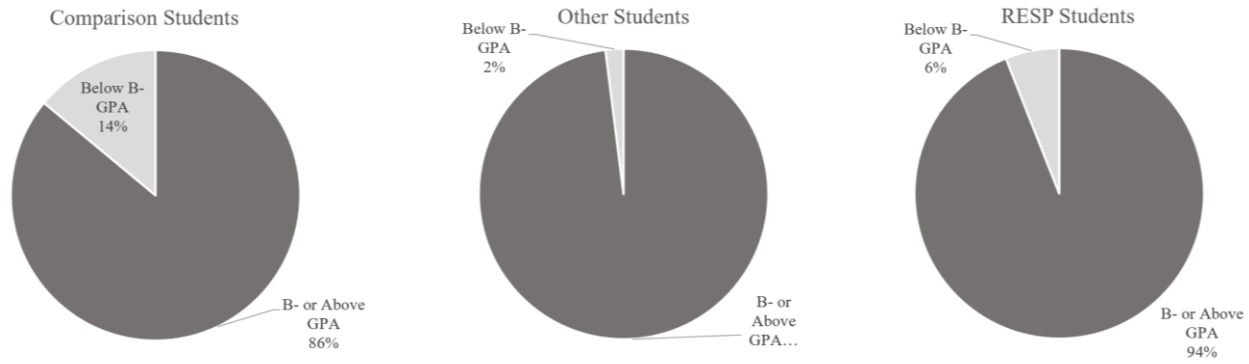

Figure 2. Distribution of B- and above GPAs by student status

Discussion

First, high school preparation predicted STEM students' graduation GPA. This is noteworthy in its long-term implications and demonstrates that high school preparation impacts STEM students

through their years in college. This finding may also indicate that using high school STEM preparation to identify potential participants for RESP is an appropriate criterion.

Second, RESP participation, controlling for high school preparation, did not predict STEM students' cumulative GPAs. Students in the non-comparison, non-RESP condition performed better in terms of their final GPA than both RESP and comparison students, and RESP students did not outperform comparison students.

Third, we examined a more specific program goal: to graduate more students with at least a B- average GPA than the comparison students. We found that RESP students had a slightly higher percentage of students who met this criterion, although the difference did not reach statistical significance. Nevertheless, this finding is some indication that the program might improve the grades of students who would otherwise struggle the most in STEM (by leaving fewer students at the bottom of the GPA distribution).

Finally, we found that RESP students were significantly more likely to graduate as a STEM major than a comparison condition of similarly underprepared students. The program appears to improve retention, bringing the STEM retention rate to almost identical to the reference group of more prepared STEM students.

Overall, although RESP participation did not predict cumulative GPAs of STEM majors, the program appears to improve STEM degree persistence and might ensure that more of the program's STEM graduates achieve at least a B- cumulative graduation GPA than comparison students. The primary strength of RESP may be in increasing retention rather than academic performance, an outcome that aligns with the national call for universities to produce more STEM graduates entering the workforce.

Limitations

As an applied intervention with many factors beyond our control, our analyses cannot fully account for all possible variables. Notably, participation is not required for admission into the university, meaning that this experimental design is quasi-experimental (i.e. assignment is not random, and selection bias is possible). However, prospective RESP students are contacted personally by a program director to strongly encourage participation. Students in the experimental versus comparison categories could nevertheless differ based on characteristics we are unable to capture.

Future Directions and Conclusion

This study explored the effectiveness of the Rice Emerging Scholars Program, particularly in analyzing long-term objective academic outcomes, which many bridge programs and other interventions do not report [5]. RESP is ongoing, meaning that a new cohort of experimental and comparison students will graduate every year, and our sample size will increase, enabling us to find effects where they exist. Our next steps for this line of research include analyzing career outcomes data for students in all three categories, as the university asks all students to report their first job when they graduate. These analyses will offer greater insight into whether RESP students enter STEM fields, and into which fields, when they graduate.

In summary, we are encouraged by these results and optimistic about the impact of the intervention, especially in terms of its contribution to improved STEM retention rates. We will continue to work with program administrators and directors to explore ways to increase course performance over students' years in college, as well as continue to focus on improving less prepared students' retention in STEM.

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