The Effect of Peer Tutoring in Reducing Achievement Gaps: A Success Story*

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Abstract

We describe the effects of three semesters of a newly implemented peer tutoring program at Humboldt State University, which is classified as a Hispanic-Serving Institution. The peer tutoring program narrowed the gap between Under-Represented Groups (URGs), Pell Grant recipients, Females and First-Generation students versus the overall student population. Statistical methods were used to test whether tutoring has helped to reduce this gap. Our results suggest that tutoring not only shrunk the achievement gap but it reduced the failure rate over 50%.

1 Introduction

Student success is a widely studied problem in computer science education. Much of that research has focused on the overall student success rate while ignoring traditionally Under-Represented Groups (URGs). At our institution,

California State University, women and minorities remain underrepresented groups, whose success requires urgent attention.

Our University is one of 23 campuses in the California State University (CSU) system. Unlike the research-focused University of California system, the CSU focus is on teaching and educational access. Most campuses in the CSU have only a handful of master's programs, hence they are typically classified as Carnegie IIA institutions [4]. The CSU comprises almost half a million students and is one of the most diverse student bodies in the United States [8]. Our University in particular is classified as a Hispanic-Serving Institution, and first-generation students also are well-represented in our classrooms.

Like many institutions, ours computer science program has gateway courses which impede progress of URG students. Our MATH 253: Discrete Mathematics course has traditionally been such a gateway course. In an effort to address this, we decided to start a peer tutoring program not only for this course, but for all our bottle-neck and gateway courses. Peer tutoring is known to help increase the student retention rate [6] as well as the overall passing grade [1].

As reported by Hart [2] peer tutoring increases student motivation towards learning. But merely making tutoring available does not necessarily guarantee success [7]. Success also requires mentorship for the tutors, dedication from the students requesting assistance, and possibly, adjustments to the tutoring format. We hypothesized that a more carefully structured implementation of peer tutoring could help close the achievement gap.

Figure 1 describes the distribution of URG students in the CS program over the past five academic years. We see a growing proportion of URG students over time. As our student population is becoming more diverse, there is greater need for programs such as peer tutoring to help close the achievement gap. Here we report on a comparison of student performance across three sections of Discrete Mathematics offered by different faculty, with a combined total of 87 students. We aim to answer the following question: "Can peer tutoring help reduce the achievement gap between URGs and non-URG students?"

2 Methodology

Our peer tutoring program was the first offered for Discrete Mathematics and the other courses it supported. Tutoring services were offered on a first-come first-served basis for Discrete Mathematics. The experiment ran for three consecutive semesters (Spring 2018, Fall 2018 and Spring 2019). The three courses were taught by three different instructors and the courses combined had 87 students. Students had the option of attending free peer tutoring services when they needed help, and were encouraged to do so by all three instructors. Tutoring was offered Monday through Thursday in the evening for a total of 20 hours

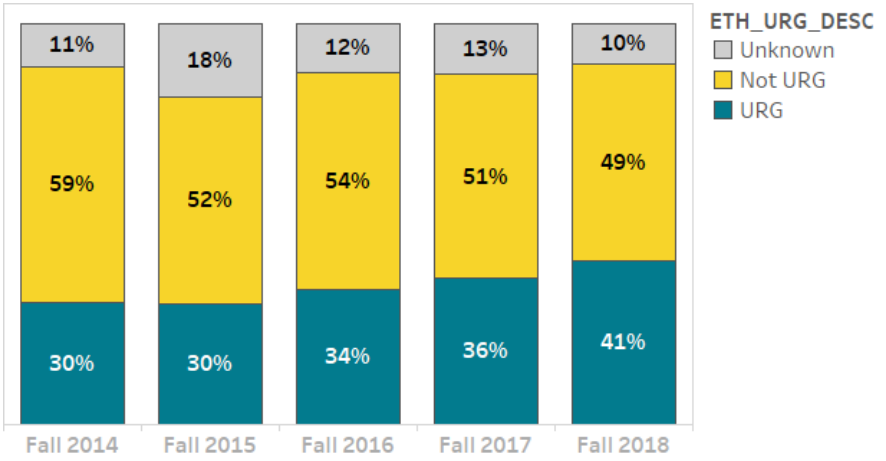

Figure 1: Student Enrollments

per week. Tutoring attendance data were tracked. Only 19 students chose to take advantage of the tutoring services. There is no indication that only weak students participated in the program, but rather a mixture of students with different experiences, backgrounds and skills. The CS program has on average 180 students.

The tutor helps only one student at a time and restricts the contact to no more than 5 minutes when the center is busy. The tutor is instructed how to guide students to solutions through the questions and similar examples without solving the homework for them. Tutors do not just review homework, but help students develop confidence in reaching their answer and becoming independent learners. On average each tutor is trained 16 hours over a period of 2 to 3 days. This is a paid mandatory training. The training was conducted by experts at our Center of Teaching and Learning in collaboration with the university Learning Center. Currently the tutors are expected and scheduled to be able to help with more than 3 courses, including all of the 100-200 level CS department courses. All of the tutors are selected after completing our gateway courses (CS 2 and Discrete Mathematics) which are often taught by the peer-tutoring program creator. Prospective tutors must earn an A grade on their overall homework and at least an A- on their course grades. Those who display good communication skills are invited to apply for the position after a brief interview. We started with 4 tutors the first semesters (All males, 1 URG) and now we have 8 (5 males, 3 females) with a combined 4 LatinX students (URG) and one female non URG.

Since instructor approaches could account for substantial variance in suc-

cess rates, all three instructors agreed to teach using the same text, *Discrete Mathematics with Applications* by Susanna Epp, and keeping materials handed out (including syllabi, assignments, and study guides for exams) as similar as reasonably possible given their teaching styles. Further, exams were crafted with an effort to keep problems at similar difficulty levels and content mixes (reuse of exams was impossible since failing students would reappear in the later semesters). Final grade formulae were kept similar, though differences necessarily existed due to components graded and slight percentage weighting differences. One instructor taught the Spring 2019 semester as a new preparation while the other instructors were more experienced with the course, but this did not affect the data appreciably. Likewise, the small adjustment from the 4th Edition of Epp's text to the 5th Edition for the third semester does not seem to have affected data appreciably.

There were some noteworthy differences between the instructors' offerings. The Fall 2018 instructor used in-class worksheets to increase student engagement, but the other two did not. And the Spring 2019 instructor was unable to complete the final chapter of the outlined course owing to time lost due to both illness and inexperience with the class. We remain uncertain how these differences may have affected the data.

We used the following formula to compute the students' success rate based upon counts of final grades assigned:

$$Success\_Rate = |A, B, C|/|A, B, C, CR, D, F, NC, W, WU, I|$$

Hence a "success" in this view is that the student passed the course at a level adequate to continue on in the computer science program.

3 Results and Statistical Data Analysis

We obtained institutional data on student demographics and compared success rates for specific groups of students. Tables 1, 2, 3 and 4 summarize success rates for students who declared themselves members of Under-Represented Groups, First Generation, Legal Sex or Pell Grant versus the rest of the students. Figures 2, 3, 4, and 5 illustrate the success rates for these partitions.

We used Fisher's exact test to check if the observed differences in the success rates are statistically significant (all the p-values are above 0.05). Table 5 shows the p-values obtained by applying Fisher's test to each of the contingency tables above. We used Fisher's exact test because the sample size is small.

We conclude that after applying peer tutoring, there is no statistically significant achievement gap. It is interesting that only 19 students out of 87 attended tutoring at least one tutoring session during the semesters given that

Table 1: URGs

	Fail	Pass
URG	7	27
Not URG	8	32
Unknown	6	7
Total	21	66

Table 2: First Generation

	Fail	Pass
First Gen	11	35
Not First Gen	7	25
Unknown	3	6
Total	33	66

Table 3: Legal Sex

	Fail	Pass
Female	5	17
Male	16	49
Total	21	66

Table 4: Pell Grant

	Fail	Pass
Pell Grant	15	38
No Pell Grant	6	28
Total	21	66

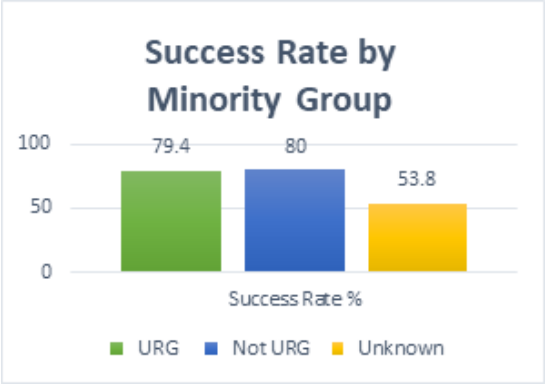

Figure 2: Success Rate by Minority Classification

students are always asking for help. Table 6 summarizes the characteristics of those students.

The failure rate among the non-URG students is 20% (one of the lowest failure rate groups) whereas the failure rate among those who attended at least one hour of tutoring is 10% even though the majority of those who participated in tutoring were at risk students. So students who attended at least one hour of tutoring had less than half the failure rate of all other student groups.

Figure 6 was obtained from institutional data that shows the achievement gap between URGs and non-URGs before and after the peer tutoring was established in spring 2018. It is hard to interpret the graph given the fluctuation

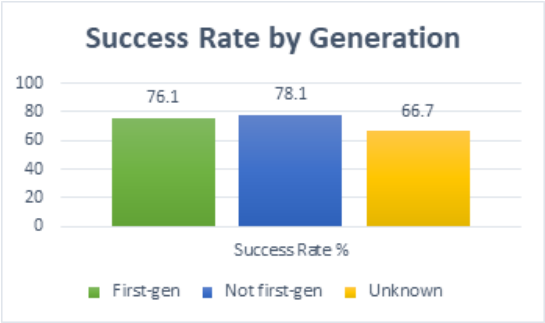

Figure 3: Success Rate by Generation Status

Figure 4: Success Rate by Legal Sex

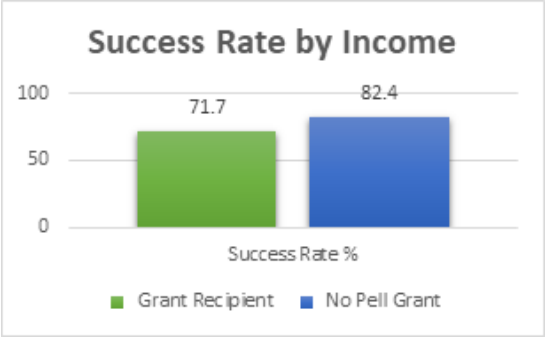

Figure 5: Success Rate by Financial Need

in the number of enrolled students and the fact that some students chose to not disclose their URG status. However, we note that the achievement gap

Table 5: Test of Statistical Significance

	P-value for Fisher's Exact Test
Under-Represented Group	0.152
First Generation	0.817
Legal Sex	1.000
Pell Grant	0.311

Table 6: Student Demographics and Tutoring Participation

	Percentage Who Participated in Tutoring
Pell Grant Recipient	90%
First Generation	74%
Females	53%
URG	47%
URG Status Not Declared	15%
All Students	22%

between URG and non-URG students is closed in the final semester. We will gather further data to see if this continues. We also note that students who choose not to disclose their URG status generally fare less well than either URG or non-URG students.

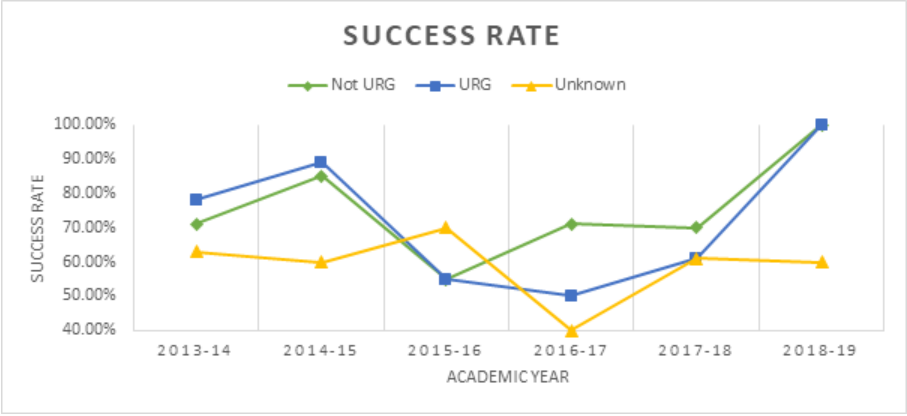

Figure 6: Achievement Gap

4 Conclusions and Future Work

We note that our peer tutoring study suffers from limitations common to research in small computer science programs. In particular:

1. The data did not come from a randomized experiment so the effect of lurking factors could not be accounted for.
2. The courses were taught by three different instructors who used slightly different grading weights, so the effect of the instructor and the grading weights could not be separated from the effect of tutoring.
3. The students themselves differed between offerings. In particular, we have no control over or adequate student representation for ethnic or cultural differences, which are known to affect success in STEM disciplines [3].
4. The fact that tutoring was available does not imply that every student utilized it. Students who chose to seek help benefited from this service while others did not.
5. Only 22% of the students enrolled in the three sections of this class participated in tutoring program. Instructors should promote tutoring and encourage students to utilize it to maximize the benefit.

Despite this, we are confident we have demonstrated that peer tutoring may have a positive impact on success rates of URGs. But why might this be so?

Our approach to peer tutoring may have created a sense of normalcy for URGs who have fewer college graduates in their social networks. Faculty encouragement may have led some to attend sessions and not feel awkward doing so. Some may have persisted because of the one-on-one environment, where dominance or competition with other students no longer existed. A success with this likely would increase self-efficacy. Simon et al demonstrated through motivational modeling that this could contribute to student success in a quantifiable manner [5]. It is worth noting that Figure 6 showed students who don't declare URG status are particularly susceptible to failure. We hypothesize that these students in particular lack self-efficacy and that interventions targeting this may help.

Hence, we are considering further data gathering and analysis of our results in light of this research to see if motivational models predict success. If so, we believe it may be possible, through short questionnaires, to identify students likely to fail Discrete Mathematics at the start of the course, and redirect them through peer tutoring and other compensatory pedagogy to improve their success rates.

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