The Effect of Supplemental Instruction on Transfer Student Success in First-Semester Calculus

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the recommended strategies require users to employ an actual process and not just sure will power. For example, the Stopping the Distraction exercise (page 108) teaches a process for cutting off the distraction and focusing on the goal instead of just saying "you must concentrate."

What I like most about Bernstein's strategies is their connection to our broader lives beyond test taking. My two favorite statements in the book are "...in the end they [thoughts] determine the course of our lives" (page 118) and "It is our experiences and the way we deal with them that shape us into what we are (page 158)." He asserts that life is a series of trials or tests and that without experiencing trials or tests, we would not grow become stronger, more skillful or more experienced. He challenges the reader to consider how he or she faces tests and to accept these tests as opportunities to grow.

Bernstein's approach to achieving test success is beneficial to test takers in various spheres from high school to college to working professionals. The comprehensive approach to dealing with the causes of test-related stress help readers prepare for successful experiences with test preparation and test taking. The straightforward language of the book makes it a quick read and having the opportunity to pin point specific areas of concern makes using the book even easier. Learning skills professionals will no doubt find this book valuable in their work supporting student success. I believe it is a good personal library addition.

The Effect of Supplemental Instruction on Transfer Student Succeess in First Semester Calculus

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Abstract

This study focused on the impact of Supplemental Instruction (SI) on student achievement in first semester Calculus for transfer students over a three-year period. Transfer students participating in SI achieved dramatically higher passing rates and course grades than did non-SI transfer students, despite no significant differences in academic predictors between the two groups. The results here indicate that while SI has been shown to be an effective tool for many students, the academic and social elements of SI may be especially significant for STEM transfer students enrolled in gateway courses such as first semester Calculus.

Introduction

Nearly thirty-five years ago, University of California Berkeley sociologist Lucy Sells (1978) coined the term "critical filter" to describe required mathematics courses as being gateways to keeping students out of mathematics-based fields. These two powerful words have continued to be at the heart of a national conversation among those concerned with the marginalization of groups of students out of

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mathematics-based disciplines (e.g. Astin, 1997; Drew, 1996, 2011; Pascarella & Terenzini, 1991, 2005; Tinto, 1994, 2012; Tobias, 1990). In particular, transfer students who major in science, technology, engineering, and mathematics (STEM) fields are often discouraged by the hierarchical curricula that can prevent students from earning a degree in a timely way. In addition, the "culture shock" of attending a new – and often much larger – institution can have an adverse effect on student achievement, particularly during the first year at the four-year institution (Astin, 1997; Drew, 2011; Tinto, 2012).

Since the late 1970s, supplemental instruction (SI) has been used to help support student success in courses that have traditionally had high non-success rates, where success is defined as a grade of C or higher, with non-success being any other grade outcome. Developed at the University of Missouri, Kansas City (UMKC, 2012), the goal of SI is to improve retention and success of undergraduates who will enter STEM careers. Further, SI aims to reduce the achievement gap between groups of students who have traditionally been underrepresented in the STEM fields (e.g, Bonsangue, 1994; Treisman, 1985). Supplemental instruction is neither tutoring nor having students do extra recitation assignments. Rather, students work in structured collaborative groups on challenging problems based on timely material presented in their lecture classes. An undergraduate student, with strong communication skills and understanding of the content, leads the SI sessions. This is a central element of the program, since students are often more apt to reveal their course weaknesses to a peer than to a professor. SI leaders often attend the professor's lecture each day to ensure that their SI sessions are current and to act as a role model for students in the course. SI leaders then meet with students at least three hours per week to creatively work on problems and study skills based on that week's lessons in a highly interactive setting (Hurley et. al., 2006).

A number of studies have documented the effectiveness of SI in college and university- level STEM disciplines, including biology (Rath et. al., 2007); chemistry (Gosser & Roth, 1998; Lewis & Lewis, 2005; Rath et. al., 2012); physics (Hake, 1998), and mathematics (Fayoski & Macmillan, 2008). Other studies have shown positive SI impacts in developmental biology courses (Moore & LeDee, 2006) as well as other "barrier" courses (Bronstein, 2008; Henson & Shelley, 2003; Mason & Verdel, 2001). Moreover, there is evidence that SI can have positive effects on students' self-efficacy and performance in STEM majors long after the SI-based course has ended (Bonsangue & Drew, 1995; Gattis, 2000).

Supplemental Instruction at CSUF

California State University Fullerton (CSUF) is a large urban commuter institution comprised of more than 35,000 students. Its diverse student body is evidenced by the fact that there is no ethnic majority group. More than one-third of all upper-division students come to CSUF as transfers. While the size of CSUF is a positive factor in providing a variety of program offerings, it also can be a negative factor from the student's point of view, especially for students new to the institution, including first-time freshmen and transfer students. At a large school such as CSUF, it may be difficult for students to meaningfully connect with faculty, students, and programs. This disconnection has been identified as a key factor in student attrition (e.g., Astin, 1997; Tinto, 1994).

To help strengthen academic achievement in STEM, as well as to help students feel more connected academically, in 2008 CSUF implemented four SI sections in first semester Calculus and Evolution and Biodiversity, modeled after the University of Missouri-Kansas City SI program. In Spring 2009, ten SI workshop sections were offered in these courses as well as Pre-Calculus and second semester Calculus. For Fall 2009 additional courses were added, including Organic Chemistry I and College Algebra, bringing the total number of SI workshops to 17. Organic Chemistry II and Physical Chemistry II were added in Spring 2010, and SI workshops increased to 20 sections. The program continued to gain momentum in Fall 2010. SI workshops increased to 35 and added courses, incorporating Cellular Basis of Life and three gateway Computer Science courses: Introduction to Programming; Programming Concepts; and Data Structure Concepts. In Spring 2011, CSUF fielded 39 SI sections, all entirely funded by external grants. Through the end of the Spring 2011 semester, approximately 3,000 students have been involved in one or more sessions of the SI workshops at CSUF.

This study focuses on the achievement of students taking first semester Calculus and the impact of supplemental instruction in this course. The data were gathered as part of the reporting on SI to granting agencies and institutional assessment of the program. No specific groups of students, other than by SI participation status, were targeted in the study.

Sample All Students

A total of 589 students majoring in a STEM discipline who were enrolled in first semester Calculus during the six semesters from Fall 2008 through Spring 2011 were included in the study. Of these, 297 students were SI participants (treatment group) and 292 students were non-participants (control group). The control group was chosen using systematic sampling of students in the same sections of first semester Calculus as the SI participants.

In the treatment (SI) group, 161/297 (54.2%) were identified by the university as having underrepresented minority (URM) status, including African-American, Hispanic/Latino, Native American, and Pacific Islander students; 136/297 (45.8 %) were identified as non-URM (including white/non-Hispanic and Asian students). In the control (non-SI) group, 126/292 (43.2%) were URM students, while 166/292 (56.8 %) were non-URM students. In addition, 132/297 (44.4%) of the students in the treatment group were women, compared with 89/292 (30.5%) of the students in the control group. Moreover, 136/302 (45.0%) of the non-URM students participated in SI, while 161/287 (56.1%) of the URM students participated in SI. Table 1a provides SI and non-SI participation frequencies by sex and URM status for all students.

Table 1a: SI and non-SI Participation by Sex and URM Status, All Students

		SI Non-Participant	SI Participant	Total
Non-URM	F	49	51	100
	M	117	85	202
	Total	166	136	302
URM	F	40	81	121
	M	86	80	166
	Total	126	161	287
Total	F	89	132	221
	M	203	165	368
	Total	292	297	589

Table 1b: SI and non-SI Participation by Sex, URM Status, and Transfer Status

		SI Non-Participants		SI Participants		Total	
		Native St.	Trans. St.	Native St.	Trans. St.	Native St.	Trans. St.
Non-URM	F	37	12	45	6	82	18
	M	99	18	66	19	165	37
	Total	136	30	111	25	247	55
URM	F	36	4	75	6	111	10
	M	80	6	77	3	157	9
	Total	116	10	152	9	268	19
Total	F	73	16	120	12	193	28
	M	179	24	143	22	322	46
	Total	252	40	263	34	515	74

Native Students and Transfer Students

The data from Table 1a was broken down by transfer status, with each student identified as a having transfer status or non-transfer (native) status. Thirty-four of the 297 students (11.4%) in the treatment group and 40 of the 297 students (13.5%) in the control group enrolled in first semester Calculus were identified as transfer students. For the treatment (SI) group, 9/34 (26.5%) were URM students. For the control (non-SI) group, 10/40 (25.0%) were URM students. In addition, 12/34 (35.3%) of the students in the treatment group were women, compared with 16/40 (40.0%) of the students in the control group. Moreover, 25/55 (47.5%) of the non-URM students participated in SI, while 9/19 (47.4%) participated in SI. T1b provides SI and non-SI participation frequencies separately by sex and URM status for native students and transfer students.

Method

Using a standard 4 point scale, grade points were quantified as follows: A+=4.0; A=4.0; A-=3.7; B+ = 3.3; B = 3.0; B-=2.7; C+=2.3; C=2.0; C-=1.7; D+=1.3; D=1.0; D-=0.7; F or WU (unauthorized withdrawal)=0.0. Students who withdrew from the course during the allowed withdrawal period were not included in the results. Success in the course was defined as a grade of C (not C-) or higher; non-success was defined as any other grade outcome. All data was taken directly from university records from the Office of Institutional Research and Analytical Studies.

Results

Native Students

Table 2a lists mean course grade, success rate, and high school grade point average (HSGPA) for native students by URM status and SI participation. Significant differences in grade outcomes between treatment and control groups were observed: 76.4% of the students in the treatment group were successful in the course compared to 49.3% of the students in the control group ($t>2.0$, $p<.01$). In addition, students in the treatment group had a mean course grade of 2.28, while students in the control group had a mean course grade of 1.53. No significant difference was noted between the treatment and control groups for high school grade point average ($p<0.5$, $t>.30$).

These differences were also noted when controlling for URM status. Among non-URM students, native SI participants had a success rate more than 20% higher than did non-SI students and a grade difference of two/thirds of a grade point ($t>2.0$, $p<.01$). Among URM students, SI participants had a success rate 35% higher than that achieved by non-SI students and a grade difference of more than nine-tenths of a grade point ($t>2.5$, $p<.005$). As before, no significant differences were noted between the treatment and control URM and non-URM groups for high school grade point average ($p<0.5$, $t>.30$). No significant differences were noted between men and women in either success rate or mean course grade within all groups.

Table 2a: First Semester Calculus Results by SI and URM Status, Native Students					
URM Status	SI Partic.	n	Success Rate	Course Grade	HS GPA
Non-URM	Non-partic.	136	58.4%	1.74	3.11
	Participant	111	80.6%	2.41	3.18
	Total	247	68.2%	2.04	3.14
URM	Non-partic.	116	37.5%	1.26	3.20
	Participant	152	73.3%	2.17	3.26
	Total	268	57.5%	1.80	3.24
Total	Non-partic.	252	49.3%	1.53	3.15
	Participant	263	76.4%	2.28	3.23
	Total	515	62.3%	1.91	3.19

Table 2b: First Semester Calculus Results by SI and URM Status, Transfer Students					
URM Status	SI Partic.	n	Success Rate	Course Grade	TRGPA
Non-URM	Non-partic.	30	57.7%	1.82	3.02
	Participant	25	76.0%	2.40	2.94
	Total	55	65.5%	2.08	2.98
URM	Non-partic.	10	20.0%	0.66	2.92
	Participant	9	88.9%	2.30	3.01
	Total	19	52.6%	1.44	2.96
Total	Non-partic.	40	45.0%	1.43	3.00
	Participant	34	79.4%	2.40	2.96
	Total	74	60.8%	1.87	2.98

Transfer Students

Table 2b lists mean course grade, success rate, and transfer grade point average (TRGPA) for transfer students by URM status and SI participation. As before, significant differences in grade outcomes between treatment and control groups were observed: 79.4% of the students in the treatment group were successful in the course compared to 45.0% of the students in the control group ($t>2.0$, $p<.01$). In addition, students in the treatment group had a mean course grade of 2.40, while students in the control group had a mean course grade of 1.43. No significant difference was noted between the treatment and control groups for transfer grade point average ($p<0.5$, $t>.30$).

These differences were even more pronounced when controlling for URM status. For non-URM transfer students, SI participants again had a success rate 20% higher than that achieved by non-SI students and a grade difference of about two/thirds of a grade point higher ($t>2.0$, $p<.01$). For URM students, 8 of the 9 SI participants (89 %) were successful, posting a combined mean course grade of 2.30. However, only 2 of the 10 URM non-participants (20 %) were successful, posting an aggregate mean course grade of 0.66.

No significant differences were noted between men and women in either success rate or course grade within the control group. A borderline difference ($t>1.5$, $p<.07$) in mean course grade was observed between men (2.58) and women (2.08), but not in success rate (82% v. 75%). Due to the small sample size of these subgroups, tests of significance should be used and interpreted with caution.

Analysis

As stated earlier, students in the sample were identified on a number of characteristics, including URM identification, sex, and transfer status. Although transfer students were not initially the point of focus, the data suggested that this group of students might warrant further analysis. Therefore, the data for transfer students was disaggregated from the data for all students to make a meaningful comparison of achievement in first semester Calculus by SI, URM, and transfer status. Figure 1a shows the mean aggregate course grade for non-transfer (native) students by SI and URM status. While not a time-based graph, the lines are helpful for visualizing possible impact from SI participation for the treatment group of students on "closing the achievement gap" between URM and non-URM students. Similarly, Figure 2a shows the overall success rate in first semester Calculus for native students by SI and URM status.

Using the data from Table 2b, Figures 1b and 2b give a similar line graph comparison of mean course grade and success rates by SI and URM status for transfer students.

Figure 1a:

First Semester Calculus Grade by SI and URM Status, Native Students

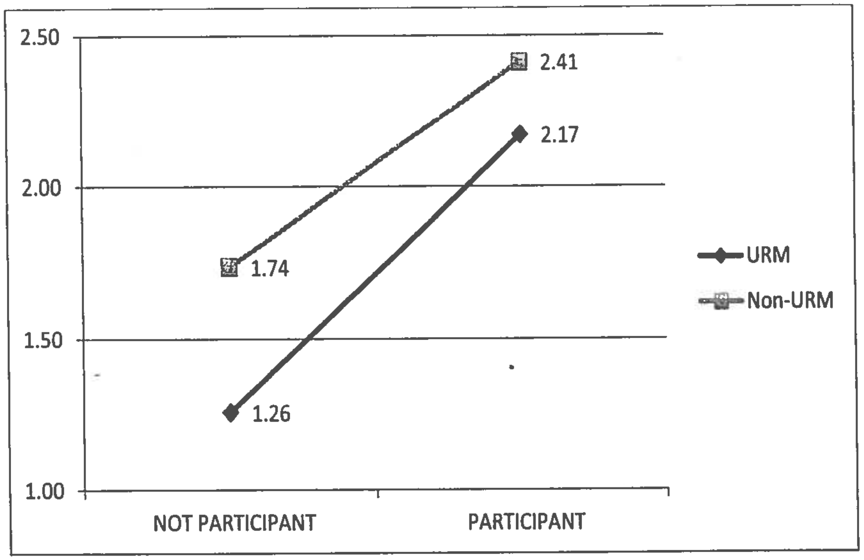


Figure 2a:
First Semester Calculus Success Rate by SI and URM Status, Native Students

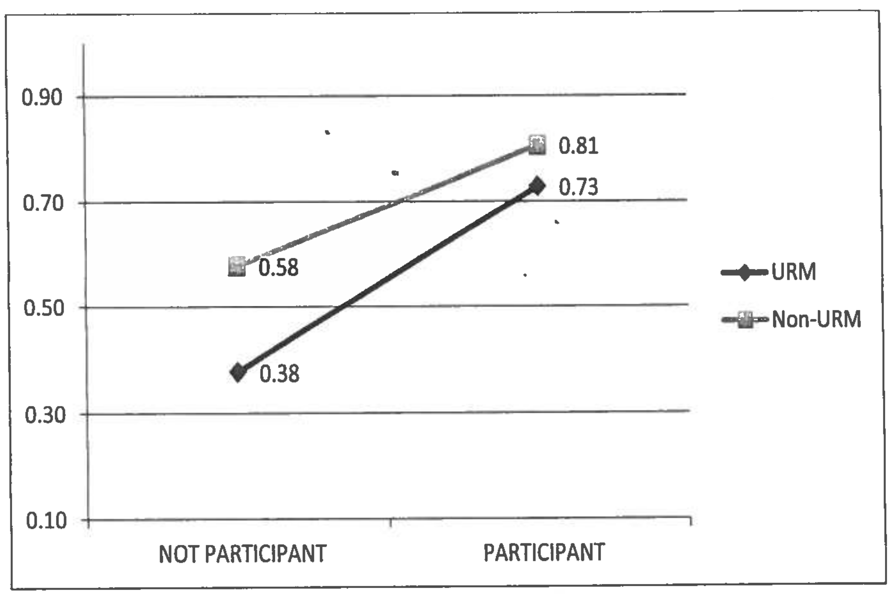


Figure 1b:
First Semester Calculus Grade by SI and URM Status, Transfer Students

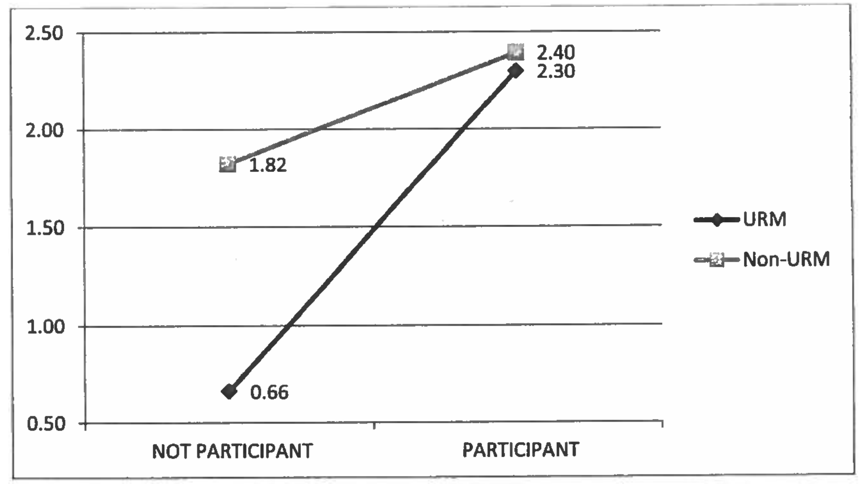
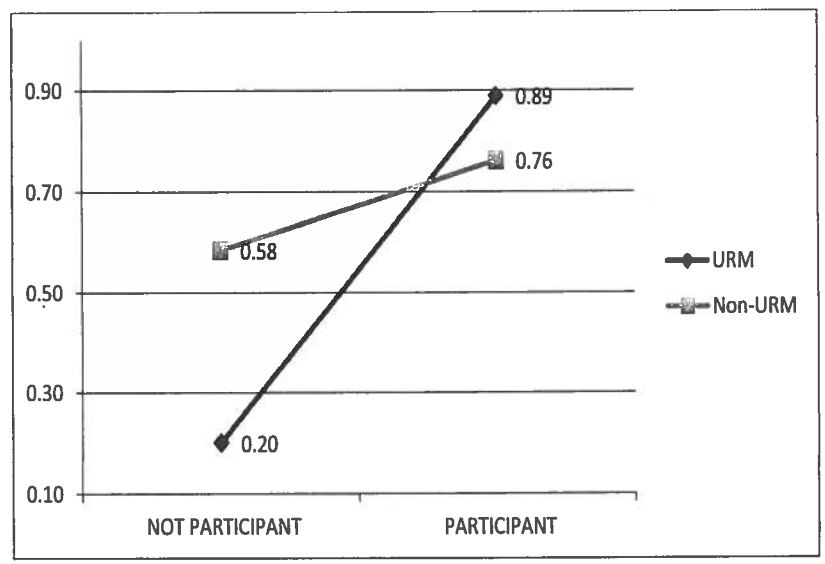


Figure 2b:
First Semester Calculus Success Rate by SI and URM Status, Transfer Students



The data presented here show that there were significant differences in course achievement between SI and non-SI students for both native students and transfer students. Indeed, figures 1b and 2b illustrate the pronounced differences that were observed for transfer students, and, in particular, for URM transfer students. While being mindful of the limited sample size, the data showed that participation in SI was linked with substantial increases in course grade and success rates for transfer students. Indeed, among transfer students participating in SI, the difference in mean course grade for URM and non-URM students (2.30 v. 2.40) was negligible, while URM transfer students actually achieved a higher overall success rate (89%) than did non-URM transfer students (76 %).

Discussion

A rich educational literature has identified predictors of success in college in general and in STEM majors, in particular. These academic variables include high school GPA, transfer GPA, SAT-M, previous mathematics courses taken, and grade in first math course taken at college have been identified as potentially contributing factors. Non-academic variables, including sex, underrepresented minority status, socio-economic status, and first generation college status have also been identified as having predictive power of student performance in college (Astin, 1997; Drew, 2011; Pascarella & Terenzini, 2005; Tinto, 2012).

Participation in intervention programs, such as supplemental instruction, is typically based on student choice rather than random assignment to specific course sections that had an SI component. The SI literature has identified bias issues in self-selection in SI participation (Gattis, 2002). While self-selection effects cannot nor should not be ignored, there is nonetheless evidence of the impact of programs such as SI. When controlling for both academic and SES factors, SI has been linked with substantial, and sometimes profound, value-added effects. Treisman (1985) found that African-American native students at UC Berkeley significantly outperformed non-URM native students when controlling for socio-economic status, HSGPA, SAT-M, and high school class rank. In a longitudinal study of native students at California Polytechnic State University - Pomona, Bonsangue (1994) and Bonsangue and Drew (1995) found that participation in SI in first semester Calculus was linked with increased timely graduation in engineering majors, especially for women students, despite significant differences in SAT scores and HSGPA favoring non-SI students. In a regression analysis, the only variable that was significantly linked to successful completion of all mathematics prerequisite courses, including two years of Calculus, was SI participation, explaining more than 50% of the variation in prerequisite mathematics completion (Bonsangue, 1994). A more recent study by Fayoski and Macmillan (2008) reported similar results in a first-year Calculus course.

While these studies have provided evidence of SI impact on student success in Calculus courses, they have generally focused on native (non-transfer) students. Although not initially focused on transfer students, the present study found evidence of significant differences in achievement in first semester Calculus for transfer students participating in a robust supplemental instruction program. These differences were even more pronounced for underrepresented minority students. The study was not designed to detect or account for self-selection; therefore, it is not known if self-selection factors would account for these differences. Indeed, such specific designs could have serious limiting effects on both the sample size and makeup since a specific group would have been "targeted" for recruitment. As discussed earlier, the SI program at CSUF focuses on courses with traditionally high non-success rates rather than on particular groups of students enrolled in those courses.

Based on data that was obtainable from institutional records, the current study found no differences in transfer GPA between transfer students participating in SI and their non-SI counterparts. Furthermore, there were no differences in transfer GPA between SI and non-SI students for any subgroup by URM or gender status. Since fewer than half of the transfer students at CSUF take the SAT, this variable was not considered. SES variables were not specifically measured, although these have been linked with URM status (Tinto, 2012) which was identified in the present study.

Exit surveys completed by SI students showed that most students participating in SI felt that SI had a positive impact on their academic performance. Indeed, more than 90% of SI students surveyed agreed or strongly agreed that SI participation was helpful. Moreover, more than half of the non-SI students indicated that the reason they did not participate in SI was because of schedule conflicts rather than for academic reasons. In trying to minimize response bias, the survey did not include ethnic, gender, or other personally identifying questions, including transfer status. Thus, the extent to which the positive self-reported impact of SI applies to transfer SI students is unknown.

The literature on transfer student issues suggests that the academically and socially inclusive experience of SI participation is at least as salient for transfer students as native students. The results from the present study strongly support this notion and underscore the importance of the community college in the education of many college students, including those majoring in STEM. For example, at Cal State Fullerton, more than half of all upper-division students are transfer students, with the overwhelming majority transferring from the community college system. Moreover, this ratio is not unusual for large urban, comprehensive universities. Thus, high-impact practices such as SI may be a key element in the retention and success of transfer students, especially in key gateway courses.

Summary and Recommendations

This study found evidence that over a five-semester period, transfer students who participated in SI in first semester Calculus were far more successful that transfer students who did not. Transfer students participating in the program had a success rate of nearly 80 % compared with 45 % for transfer students not participating and posted a mean grade, 2.40, of nearly one full grade point higher than non-participants. Differences in course achievement between underrepresented minority students and non-URM students in first semester Calculus performance were pronounced for non-SI transfer students, yet essentially disappeared between URM and non-URM transfer students participating in SI.

While not initially targeting transfer students, this study may help contribute to the discussion of issues affecting transfer students, and especially those majoring in STEM disciplines. Programs, such as supplemental instruction, that build community based on common academic goals can have a significant impact on student achievement, especially in initial experiences in gateway mathematics and science courses for STEM majors. In general, students who are successful in their initial mathematics course are much more likely to complete a STEM degree than those who are not initially successful (e.g., Tinto, 2012). The present study suggests that this first-time experience may be critical for transfer students as well as for native students.

Based on the results discussed here, there are three recommendations that academic departments and/or STEM support programs that have SI or similar support structures may wish to consider implementing. First, incoming transfer students should be contacted prior to enrolling in STEM classes. It may be especially effective to have current upper-division STEM students make this contact via telephone, email, and/or instant messaging, to inform incoming transfer students about SI (or other) support structures that are available to them and to personally usher them into these programs. Second, recruit and enroll transfer students vigorously during the first two weeks of classes into SI programs, including classroom visitations by SI leaders or other STEM students who can serve as accessible contact persons. And third, maintain a database to track the progress of transfer students in initial STEM courses. This information would allow departments and/or programs to do timely interventions with the transfer students, as well as provide accurate and up-to-date data for reporting purposes to granting agencies or institutional funding sources. By proactively creating and maintaining effective support structures for gateway STEM courses, academic departments may help increase their own awareness of and responsibility to all students wishing to participate in a STEM field. Indeed, CSUF is working more closely now with its Transfer Center to help identify and enroll transfer students into SI courses as students or even as facilitators.

There are limitations to this study. The number of transfer students enrolled in first semester Calculus (74) was, while not trivial, limited. Specifically, the impact of SI on underrepresented minority transfer students remains more anecdotal than statistical based on the limited sample size. Variations in pre-transfer experience, such as number of semesters completed prior to transferring or initial mathematics course taken in college, were not considered.

Despite these constraints, this is the first study to our knowledge that has reported on the academic performance of this specific group – transfer students in STEM majors – and the impact that supplemental instruction can have on these students' academic success. Clearly, more research is needed to explore if the trends observed here remain apparent in other institutions and other contexts. Even with the limitations identified, this study documents that effective intervention programs can strengthen academic achievement of STEM transfer students.

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