Learning Support Services at the University of California, Santa Cruz: Students' Experiences and Educational Outcomes

Report Prepared for the Student Success Steering Committee
University of California, Santa Cruz

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Executive Summary

The Student Success Steering Committee at the University of California, Santa Cruz was formed in early 2014 to address undergraduate student retention, graduation, and time to degree on campus. In its efforts to promote these goals, the Committee funded this study to examine the role of Learning Support Services in helping students to succeed academically. This study uses data from administrative records kept by UCSC on its students' academic experiences in the 2010-11 to 2013-14 academic years.

Learning Support Services (LSS) at UCSC is intended to aid students—particularly those who are at highest-risk of academic failure—who are having difficulty in a course to master the required material and succeed in the course. It includes two primary components: modified supplemental instruction (MSI) and tutoring. MSI is a voluntary program that supports certain courses with an undergraduate learning assistant who offers one or more weekly sessions for participating students in a small group setting of 10-12 students. Tutoring takes two forms. There is small group tutoring for certain courses with no more than five students at a time and once a student signs up, attendance is mandatory. Drop-in tutoring in math, writing, and some other courses is also available to students as needed. Prior research shows that activities such as these are central to supporting student academic success, particularly for students who are socioeconomically disadvantaged or from underrepresented minorities.

The study responds to key questions posed by Steering Committee members and LSS administrators, including the extent and types of students using LSS, the relationship between LSS and several different academic outcomes, and the role of LSS in two of the most popular fields of study on campus. Below we summarize the findings.

Many students use MSI and tutoring. Among UCSC's entering freshman cohort of 2010, 22% attended MSI at least once during the four subsequent years. However, 40% of these students never enrolled in a course that offered MSI and 38% enrolled in an MSI-supported course, but did not make use of the program. When students used MSI, they attended an average of about 3 out of 9 sessions offered during the quarter. In the same group, one-third of students attended at least one tutoring session over the subsequent four years, enrolling in on average one tutoring session per quarter.

MSI and tutoring serve students who have historically been disadvantaged. Women, first generation college students, Pell Grant recipients, students who were eligible for the Educational Opportunities Program (EOP), African Americans, and Latino/a students were more likely to use MSI and tutoring than their counterparts. In addition, they attended more sessions of these programs than other students.

MSI and tutoring are associated with increases in course grades. Controlling for a variety of demographic factors, prior academic achievement, and course difficulty, each additional MSI session a student attended was associated with an average increase of 0.02 grade points over the class average, and each additional tutoring session was associated with an increase of 0.04 points. There are a number of underlying student characteristics—such as student motivation or self-efficacy—that are not captured in administrative data which might also influence course performance. To address these individual differences between students, we also compared their course grades when they used MSI or tutoring to their grades when they did not. Again we found a positive relationship between MSI and course

performance, but a negative relationship between tutoring and course performance. A possible explanation for this is that the students who were most likely to participate in tutoring were those for whom the class was the most challenging, whereas MSI may be more of a whole-class activity that attracted all types of students.[1]

Students using MSI and tutoring were as likely to be retained and graduate as other students. Controlling for a variety of demographic factors and prior academic achievement, we find that students participating in MSI and tutoring were as likely as those who did not participate to graduate in four years. Having six years of data would allow us to better examine the association between LSS participation and graduation. Those who attended tutoring were more likely to be retained year over year.

LSS supports potential biology majors. In the four years of data we analyzed, about a quarter of UCSC students declared biology-related majors and LSS supported the prerequisite courses on the way to major declaration, which are often difficult for students. MSI attendance in several of these key courses, including Biology 20A, Biology 20B, and Chemistry 1B, was associated with higher course grades for students. It was not associated with increased course grades in the other prerequisite courses. MSI was also not associated with an increased rate of biology major declaration, however complexities in determining which students planned to declare a major may have affected the results.

LSS supports potential psychology majors. Nearly 12% of UCSC students in the four years of data analyzed declared a psychology major and LSS supported the prerequisite courses for this major as well. MSI utilization was associated with higher course grades in Psychology 1, Psychology 2, and AMS 5. We find no relationship between MSI utilization in other prerequisite courses and major declaration for psychology, but again, the complexities of determining who intended to major in psychology could have clouded the findings.

Math 2 and Math 3 students struggle, even with LSS support. Both biology and psychology, as well as many other majors on campus, require students to pass Math 2 and Math 3 in order to continue in the major. LSS has attempted a variety of means to support these students, who arrive at UCSC underprepared to succeed in college math. Our analyses show that LSS support has not been associated with positive outcomes in these courses, but other underlying factors—such as student preparedness, math placement processes, and class size—must be accounted for in understanding these results.

This analysis points to Learning Support Services as a critical support for students on UCSC campus. MSI and tutoring serve students who we might anticipate are in greatest need of support and aids them to be on par with, and in some cases exceed, overall course performance, retention and graduation. As an organization, LSS uses a data-driven decision-making approach to its services and routinely tracks student course performance. In its 2014-15 report, LSS will look in more detail at its utilization and outcomes within courses, departments, and divisions and the costs associated with supporting students at each of these levels.

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[1] LSS staff reported that students tend to view MSI as an extension of the course curriculum, like a service that can be used even if the students do not feel they are at risk of performing poorly (e.g., making sure they are on the right track with homework).

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List of Exhibits

Introduction

The Student Success Steering Committee at the University of California, Santa Cruz (UCSC) was formed in early 2014 to address undergraduate student retention, graduation, and time to degree on campus. The Committee, which includes members who represent all of the campus leadership and all constituencies concerned with student success, has embarked upon a multi-faceted approach to addressing student success. One strand is to conduct research to understand how current programs on campus address student success by examining who they are serving, the types and extent of services offered, and students' subsequent academic outcomes. Toward this end, the Committee funded a study of Learning Support Services (LSS), which was conducted during the 2014-15 school year using administrative records kept by UCSC on its students' academic experiences.

The analyses covered in this report were derived from several campus goals and concerns. Student retention and graduation are top concerns, constituting two of Executive Vice Chancellor Allison Galloway's Five for 2015 goals: increasing retention rates for undergraduate students, and enhancing academic pathways to allow students to graduate in four years or less. Educational equity, or the opportunity for every student to succeed irrespective of race/ethnicity, class, first generation status, gender, or college preparation, is also a key concern that has informed this report. Educational equity is particularly central because LSS is explicitly intended to support students who have been traditionally underserved or have been educationally disadvantaged prior to attending UCSC.

Brief Description of Learning Support Services

Prior to fall 2000, UCSC offered a few small academic support programs, the most notable of which were the Educational Opportunities Program (EOP) tutoring program and the Core writing tutoring program that served targeted groups of students. In the fall of 2000, as part of a commitment to provide all students access to academic support services, the University began to offer course-specific, small, peer-guided, interactive learning activities to students enrolled in large lecture courses. This supplemental instruction was intended to assist students in courses that had proven academically challenging, but were required for declaring and completing popular academic majors. The program began with a focus on one course, Chemistry 1B, and has grown since then to support 55 courses in fall of 2015 with what is now called modified supplemental instruction (MSI).[2]

When a course offers MSI, a qualified undergraduate student acts as an MSI learning assistant. In order to qualify as a learning assistant, students must have previously taken the course and earned a B or better, and been recommended by a faculty member. Learning assistants are then trained, observed and evaluated through LSS. The learning assistants offer one (or more) 75-minute weekly interactive learning group sessions. Sessions are usually no larger than 10 to 12 students and attendance is voluntary, though students are given the chance to sign up for regular attendance. Faculty vary in the

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[2] Based on the advice of the campus committee initially appointed to oversee the development of the proposed supplemental instruction program, what is traditionally referred to as supplemental instruction on other university campuses is called modified supplemental instruction (MSI) at UCSC.

extent to which they interact with learning assistants about effective learning strategies and the choice of material to be discussed in the sessions. The learning assistant is required to attend the course lectures so as to be currently engaged in the course material and familiar with the professor's expectations of the students. Additionally, during his or her first quarter of employment, the MSI learning assistant is required to participate in weekly LSS trainings, which aim to provide learning assistants with the skills necessary to involve students in interactive learning activities and encourage and assist them to demonstrate their knowledge and critical thinking skills.

When MSI is attached to a course, all students enrolled in the course are eligible to participate in the sessions on a space-available basis. Whenever possible, LSS provides enough MSI sessions to accommodate students' desire to attend. LSS, professors, academic advisors, and other support staff on campus sometimes reach out to encourage students whose previous educational performance in related UCSC courses indicates that they may need MSI support in order to master the course material.

LSS also offers small group tutoring for both MSI supported and non-MSI supported courses. The non-MSI supported courses are typically courses that are not large enough to attract 30 or more students to seek academic support. Tutoring groups are no larger than five students and students are eligible to sign-up for and attend one or two hours of tutoring a week. Writing tutoring is offered as one-to-one tutoring unless an instructor has developed small writing groups led by a tutor as an academic support model for the course. Professors are encouraged to recommend tutors for their courses and LSS also advertises its positions through the UCSC Career Center. All tutors must have a letter of recommendation from a UCSC instructor who has taught the course or similar courses and has assessed the prospective tutor's understanding of the course material. LSS attempts to find a tutor to fulfill any student request it receives. Additionally, it is the responsibility of LSS to offer effective academic tutoring for students with disabilities by providing them with services according to the special program accommodations that the Disability Resource Center mandates.

All MSI learning assistants and tutors are required to enroll in a training course during their first quarter of employment and to participate in training activities for which they are paid in all subsequent quarters of employment. Additionally, all students who receive tutoring or MSI support each quarter are sent both mid-quarter and end-of-quarter evaluation forms via email and urged to complete them and return them to LSS. MSI learning assistants and tutors are asked to meet with an LSS staff member to discuss problematic issues communicated through the evaluations and may or may not be offered future employment depending on the situation.

Brief Summary of Literature on Effectiveness of Supplemental Instruction and Tutoring on Student Outcomes

Past research has shown that attendance in supplemental instruction and tutoring programs relates to greater academic success. Participation in supplemental instruction is related to improved GPA and higher retention among students' of varying achievement levels and academic preparation (Arendale 2001; Blanc, DeBuhr, & Martin, 1983; Ogden, Thompson, Russell, & Simons, 2003). Furthermore, the skills gained in supplemental instruction (e.g., learning study strategies) may also transfer to other

courses (Malm, Bryngfors, & Mörner, 2012). The benefits of supplemental instruction derive in part from learning course concepts, but also these services provide students with a psychological sense of competence (Ning & Downing, 2010). Supporting these findings, a systematic review of 29 published articles on supplemental instruction found that these programs predict improved grades and retention (Dawson, van der Meer, Skalicky, Cowley, 2014). There is notably less research on tutoring, but Hodges and White (2001) found that supplemental instruction but not tutoring is related to increased grade point averages (Hodges & White, 2001).

There are a variety of reasons that supplemental instruction and tutoring would lead to students' academic success. In Kuh, Kinzie, Buckley, Bridges, and Hayek's (2006) commissioned report of what matters for student success, a number of potential features of LSS are present as predictors. Engagement in academically purposeful activities beyond the classroom not only develops immediately relevant skills among students, but also increases motivation to succeed. Academic and non-academic positive peer interaction can foster sharing of knowledge about how to perform well in school as well as develop a stronger sense of belonging to one's institution. Participating with people from a diversity of perspectives and life experiences also contributes to student success. Finally, increased satisfaction with one's institution, something that may occur when receiving supplemental support from the university, is also related academic success.

Research Questions

We address the following research topics and questions in this report.

1. **MSI and Tutoring Utilization.** Utilization refers to the extent to which students enroll in courses supported by LSS and choose to attend. What percentage of students utilize LSS at least once during their undergraduate career? When students attend LSS, how many tutoring or MSI sessions do they typically attend? How does rate of utilization differ among racial, socioeconomic, first generation, and gender groups? These questions serve to assess the reach of LSS, quantifying the number and dosage of students served, and educational equity across demographic groups.

2. **Comparison of Utilizers and Non-Utilizers.** Utilizers are students who have attended at least one MSI or tutoring session during their undergraduate career whereas non-utilizers are students who have not. How do utilizers and non-utilizers differ across racial, socioeconomic, first generation, and gender groups? These questions assess reach and educational equity of LSS, but because some subsequent analyses only include utilizers, quantifying differences between utilizers and non-utilizers allows for assessment of limitations of these analyses.

3. **Relationship between LSS Utilization and Course Grades.** What is the difference in students' average course grade when they attend LSS as compared to when they do not? What is the relationship between LSS utilization and average course grade; what is this relationship after controlling for demographics, academic preparation, UCSC academic performance, and course difficulty? These questions serve to quantify the efficacy of LSS.

4. **UCSC Retention Rate.** What is the relationship between LSS utilization and retention; what is this relationship after controlling for demographics and academic preparation? These serve to address EVC Galloway's initiative to improve retention rates.

5. **UCSC Four-Year Graduation Rate.** Graduation rate refers to whether students graduated within four years of enrollment.[3] What is the relationship between LSS utilization and odds of graduation; moreover, what is this relationship after controlling for demographics and academic preparation?

6. **LSS in Specific Majors.** We selected two of the largest majors on campus and examine the role of LSS utilization in students' pathways through each. These analyses serve to quantify LSS efficacy within the two majors, which have prerequisite courses that students often find difficult.

    a. *Biology.* Success in a biology major at UCSC is largely predicated on successful completion of calculus and cell and molecular biology, classes in which students often struggle. For prospective biology majors, what is the relationship between LSS utilization and course grade in calculus and cell and molecular biology and what is the relationship between LSS utilization and odds of passing calculus and cell and molecular biology? What is the relationship between LSS utilization within all biology courses and successful major declaration? What are these relationships after controlling for demographics and academic preparation?

    b. *Psychology.* Success in a psychology major at UCSC is largely predicated on successful completion of statistics and introduction to psychology, classes in which students often struggle. For prospective psychology majors, what is the relationship between LSS utilization and course grade in statistics and introduction to psychology and what is the relationship between LSS utilization and odds of passing statistics and introduction to psychology? What is the relationship between LSS utilization within all psychology courses and successful major declaration? What are these relationships after controlling for demographics and academic preparation?

Data, Measures and Analysis Methods

Population

Students were a census of UCSC undergraduates enrolled in any quarter, except summer session, from fall 2010 to spring 2014, the four years for which LSS attendance data were comprehensively collected. Students who participated in the Academic Excellence Program (ACE), a high impact program for a small number of students in STEM majors, were excluded in these analyses because these students are already being served more rigorously through this competitive alternative program. Students during these years at UCSC were racially and ethnically diverse, with a skew towards White students (41.5%) but a large number of Hispanic/Latino/a (24.9%) and Asian (22.9%) students and a smaller percentage of

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[3] Six-year graduation rates are typically used to assess college completion. However, with the data available for this analysis, we were only able to examine four-year graduation rates.

African American/Black (3.3%), American Indian/Alaskan Native (1.2%), Pacific Islander (0.4%), International (0.7%), and Unknown (5.1%) students. Nearly half of students (47.4%) received a Pell Grant, which is often used as a proxy for low income status (i.e., students who receive Pell Grants tend to come from lower income households). First generation college students constituted 44.4% of the population. Just over half of the students (52.7%) were women. A third of the population (32.8%) met the criteria for enrollment in in the Educational Opportunities Program (EOP).

Measures

An array of student data are collected and stored by UCSC: demographic information, course enrollments and grades, MSI and tutoring attendance, majors declared and degrees earned, pre-college academic performance, and registration status, and many of these variables are measured for multiple terms. We calculated several new measures using university collected variables. We used the following types of variables in analyses, some of which are described in more detail below:

- Socio-demographic variables: gender, race/ethnicity, first generation college student, socioeconomic status (as measured by Pell Grant), Educational Opportunity Program (EOP) designation;
- Prior academic experiences: cumulative high school GPA;
- UCSC academic experiences: course enrollment and grades, four-year-graduation for the 2010 cohort, major declaration;
- UCSC academic support participation: utilization of Learning Support Services.

MSI Utilization. MSI utilization is the percentage of possible MSI sessions that students attended. This number was calculated by dividing the number of MSI sessions a student attended by the maximum number students could attend (nine, one for each week of MSI offered) for every MSI supported class in a student's enrollment history. MSI utilization within each course was then averaged across all courses to yield each student's total MSI utilization.

Tutoring Utilization. Tutoring utilization is the percentage of possible tutoring sessions that students attended. This number was calculated by dividing the number of tutoring sessions a student attended by the number of quarters that he or she was enrolled at UCSC. Sessions of small group tutoring and drop-in tutoring are counted together when calculating utilization to make analyses more parsimonious. Because of the nature of drop-in tutoring, a student could conceivably have attended tutoring any number of times for any class, so utilization was computed based on the number of quarters enrolled instead of a maximum number of sessions available.

Educational Opportunities Program Designation. Students are designated as eligible for the Educational Opportunities Program (EOP) if they are low-income or first generation, and they overwhelmingly come from under-resourced high schools. EOP provides both academic and personal support to students who are designated as EOP eligible in order to improve retention and educational success of students who continue to be underrepresented in higher education. For the present report, EOP designation was used as another demographic variable and includes all students who were EOP eligible, including both those who did and did not use program services.

Course Performance Comparisons. We compared students' course performance with and without LSS services in two different ways.

1. **Relative Course Grade.** Relative course grade is the difference between an individual's grade and the average grade in the class, averaged across every class. Relative course grade is computed by averaging every student's grade in every class to yield the class average grade. Each individual grade is then subtracted from the average to indicate how much better or worse the student did from the average; a positive number represents doing better than the class and negative represents performing worse. This number is then averaged across all courses that a student took, thus yielding the student's average total performance relative to their peers.

2. **Course Grade Difference for Each Student.** Course grade difference is the difference in GPA between courses where students utilized and did not utilize LSS. MSI course grade difference is computed by subtracting the GPA of all classes where a student utilized MSI from the GPA of all classes where a student did not. Tutoring course grade difference is calculated in the same way. Either course grade difference score represents how much higher or lower a student's GPA is when utilizing LSS as compared to when not; a positive number represents better grades when utilizing LSS and a negative represents lower grades.

Retention. We measured retention using fall enrollment. If a student was an entering freshman for a given year and was enrolled for fall of the subsequent year, that student was counted as being retained to his or her sophomore year. Students who were also enrolled in fall two and three years after their entering freshman year were retained to their junior and senior years, respectively. Because we only used four years of data, we have three cohorts for sophomore retention (2010, 2011, 2012), two cohorts for junior retention (2010, 2011), and one cohort for senior retention (2010). We also calculated total retention, which is the combination of all three retention analyses: all students from 2010-12 who were retained until fall 2013. Total retention has the benefit of increasing the population size, but it is skewed because it combines students who had more time to drop out (e.g., the 2010 cohort) with students who had less (e.g., the 2012 cohort).

Prospective Biology and Psychology Major. Prospective biology major was measured using two criteria: whether the student had enrolled in any of the introductory biology courses (BIOL020A, BIOE020B, or BIOE020C) and whether the student had enrolled in any of the introductory chemistry courses (CHEM001A, CHEM001B, CHEM001C). If a student had taken one or more of each set of courses, that student was considered a prospective biology major. Prospective psychology major was measured using one criterion: whether the student had enrolled in Introduction to Psychology (PSYCH001). All students who had taken PSYCH001, were considered prospective psychology majors. This method, although an imperfect measure of intent to declare the major, was used in lieu of proposed major because that information was not available to us.

Results

Overall Utilization Rates

We first analyzed LSS utilization among different groups of UCSC students. We assessed overall MSI and tutoring attendance to understand the scope of the program. Next, we statistically tested demographic differences in utilization to understand the extent to which LSS supports students who tend to perform better and worse in college. Finally, we described the demographic characteristics of LSS attendees.

Among UCSC's entering freshman cohort of 2010 who remained enrolled for four years until 2014, (N=2,452), 22.3% attended MSI at least once during the first four years of their undergraduate career. As shown in Exhibit 1, however, 39.7% of this cohort never enrolled in a course that offered MSI and thus could not attend a session; among students who enrolled in at least one course that offered MSI, 36.9% attended at least one MSI session. Because the number of MSI sessions that students attend depended on the number of MSI supported courses that they took, we computed an MSI utilization rate for every student. MSI utilization is the number of MSI sessions that the student attended divided by nine, the number of sessions that they could have attended (for each week of the quarter where MSI is offered) multiplied by the number of MSI supported courses the student enrolled in. This measure both accounts for differences in the number of MSI supported courses in which students enrolled and allows for analyzing students who were enrolled during any years between 2010-14 instead of just the entering freshman cohort. Across all students enrolled in any quarters at UCSC during this time period (N=31,366), 45.5% of students enrolled in courses offering MSI used it at least once, and attended an average of 37.6% of the offered sessions.

Exhibit 1: MSI Supported Course Enrollment and Utilization
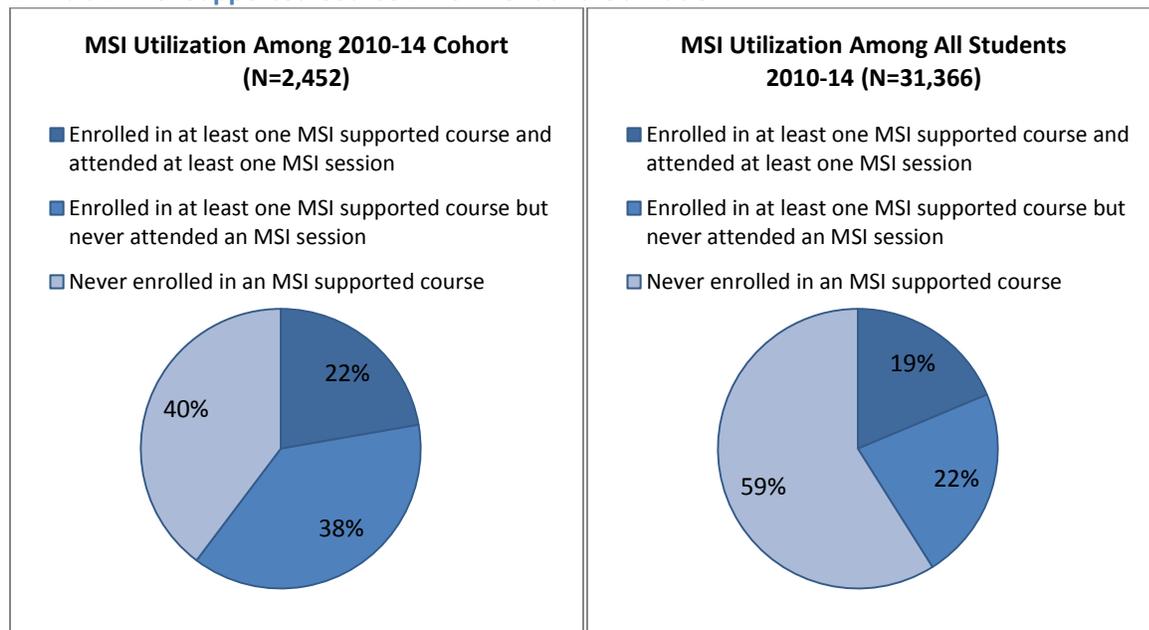
MSI Utilization Among 2010-14 Cohort (N=2,452)

- Enrolled in at least one MSI supported course and attended at least one MSI session
- Enrolled in at least one MSI supported course but never attended an MSI session
- Never enrolled in an MSI supported course

22% / 38% / 40%

MSI Utilization Among All Students 2010-14 (N=31,366)

- Enrolled in at least one MSI supported course and attended at least one MSI session
- Enrolled in at least one MSI supported course but never attended an MSI session
- Never enrolled in an MSI supported course

19% / 22% / 59%

Population: 2010-14 Cohort constitutes all students who were enrolled as freshmen in 2010 and were registered for classes through to 2014. All Students constitutes every undergraduate student who attended UCSC, excluding summer session, at all during any of the years between fall 2010 and spring 2014.

As shown in Exhibit 2, 32.5% of the entering freshman cohort of 2010 who were retained until their senior year attended at least one tutoring session. In order to analyze more students than the 2010 cohort, we computed each student's tutoring utilization, which is the number of tutoring sessions attended per quarter enrolled at UCSC. This normalizes tutoring attendance across students for whom we have varying years of data (e.g., students who were seniors in 2010-11). Among all students enrolled during 2010-14, 11.5% attended at least one session, and these students attended, on average, 0.96 sessions per quarter.

Exhibit 2: Tutoring Utilization
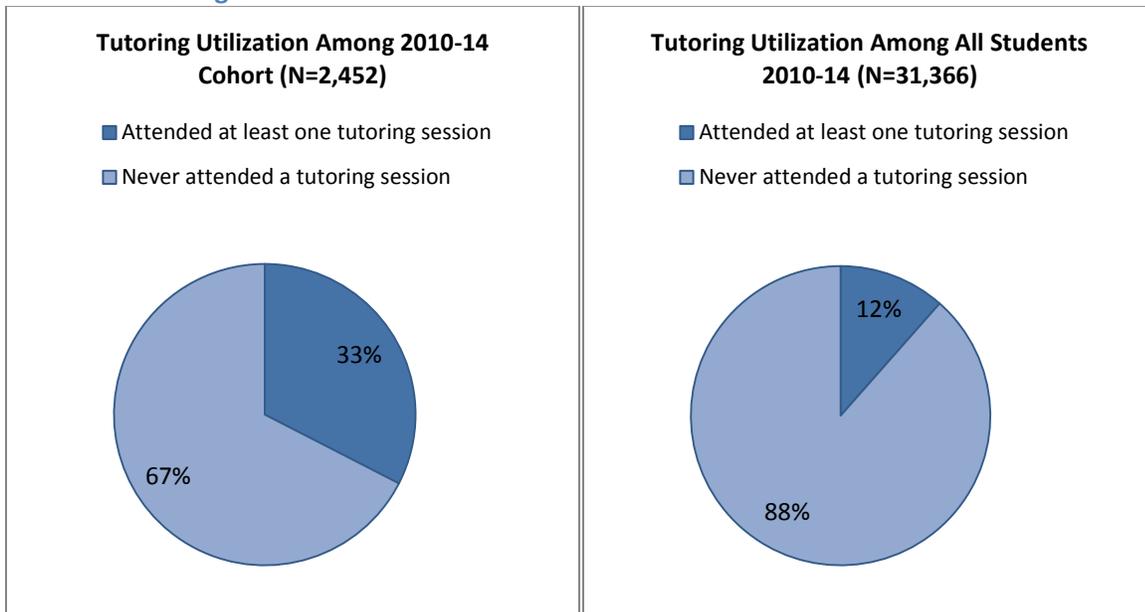
Tutoring Utilization Among 2010-14 Cohort (N=2,452)	Tutoring Utilization Among All Students 2010-14 (N=31,366)
■ Attended at least one tutoring session	■ Attended at least one tutoring session
■ Never attended a tutoring session	■ Never attended a tutoring session

Population: *2010-14 Cohort constitutes all students who were enrolled as freshmen in 2010 and were registered for classes through to 2014. All Students constitutes every undergraduate student who attended UCSC, excluding summer session, at all during any of the years between fall 2010 and spring 2014.*

Learning Support Services Utilization Among Student Subgroups

There were a number of demographic differences in MSI utilization: women, first generation, Pell Grant recipient, EOP-eligible, African American, and Latino/a students were more likely to utilize MSI at all (i.e., attend at least one session) and generally utilized more (i.e., attended more sessions) than their corresponding demographic peers. These results suggest that LSS was used more by groups that have historically been disadvantaged. We used chi-square tests with follow up z-tests of column proportions to assess differences between demographic groups' odds of ever utilizing MSI and independent samples t-tests and a one-way ANOVA to analyze differences in utilization rates among students who used MSI; all results are shown in Exhibit 3.

A statistically significantly larger percentage of women (52.2%) attended MSI as compared to men (38.5%), and women utilized significantly more (41.6% of available sessions) than men (31.7%). Over half (51.5%) of first generation college students attended at least one MSI session and attended at a rate of 41.6%, whereas only 40.3% of non-first generation college students attended MSI and attended at a rate

of 32.8%; both differences were statistically significant. Pell Grant recipients were also significantly more likely to have attended MSI (49.8%) and attended significantly more often (40.0% of sessions) than their non-recipient peers, for whom 41.2% attended MSI and at a rate of 34.6%. The same pattern emerged for EOP-eligible students compared to EOP-ineligible students: 53.6% of EOP-eligible students attended MSI but only 40.3% of EOP-ineligible students attended, EOP-eligible students attended at a rate of 43.0% but EOP-ineligible students attended at a rate of 32.9%, and these differences in both likelihood of ever attending and rate of attendance were statistically significant. A number of differences between the eight racial/ethnic groups were found. Most notably, Hispanic/Latino/a and African American/Black students were significantly more likely to ever attend MSI (53.6% and 52.6% respectively) and attended at a significantly higher rate (44.1% and 43.5% respectively) than White students (38.6% attended MSI at a rate of 32.9%).

Exhibit 3: Differences in MSI Rates among Demographic and Academic Groups

Demographic Characteristics	Percentage of Students who Utilized MSI	Number of Students who Utilized MSI	Extent of MSI Utilization among Students who Attended MSI
Gender			
Women	52.2%*	3,474	41.6%*
Men	38.5%	2,369	31.7%
First Generation Status			
First Generation	51.5%*	3,141	41.6%*
Not First Generation	40.3%	2,554	32.8%
Pell Grant Recipient Status			
Pell Grant Receipt	49.8%*	3,239	40.0%*
No Pell Grant Receipt	41.2%	2,615	34.6%
Educational Opportunities Program			
EOP Eligible	53.6%*	2,722	43.0%*
Not EOP Eligible	40.3%	3,132	32.9%
Race			
Hispanic / Latino/a	53.6%[b]	2,080	44.1%[b]
Asian	45.8%[c]	1,618	32.9%[ac]
African American / Black	52.6%[bc]	247	43.5%[b]
White	38.6%[a]	1,686	32.9%[ac]
Pacific Islander	39.3%[abc]	22	49.0%[abc]
American Indian / Alaskan Native	42.4%[abc]	56	36.6%[abc]
International	38.1%[ac]	56	47.0%[ab]
Unknown	32.8%[a]	89	33.9%[abc]
Total	**45.5%**	**5,858**	**37.6%**

Statistically significant differences between groups at the .05 level, a-c Groups with the corresponding letter do not differ at the .05 level (i.e., groups who do not share a letter significantly differ).

Note: Statistically significant differences between groups signify that there is a high probability that the difference between the means is not due to random chance. Population: Students included in the second column are all undergraduate students who attended UCSC, excluding summer session, at all during any of the years between fall 2010 and spring 2014. Students included in the last two columns are the subset of students who attended at least one MSI session.

A pattern nearly identical to MSI utilization appeared when assessing differences between demographic groups' tutoring utilization. Women, first generation, Pell Grant recipient, EOP-eligible, African American, and Latino/a students were more likely to utilize tutoring and generally utilized more than their corresponding demographic peers. Results indicated that tutoring was used more by historically underserved demographic groups. Again, we used chi-square tests with follow up z-tests of column proportions to assess differences between demographic groups' odds of ever utilizing tutoring and independent samples t-tests and a one-way ANOVA to analyze differences in utilization rates among students who used tutoring; all results are shown in Exhibit 4.

Exhibit 4: Differences in Tutoring Rates among Demographic and Academic Groups

Demographic Characteristics	Percentage of Students who Attended Tutoring	Number of Students who Utilized Tutoring	Average Number of Tutoring Sessions per Quarter
Gender			
Women	14.9%*	2,383	1.02*
Men	8.5%	1,217	0.86
First Generation Status			
First Generation	16.8%*	2,142	1.08*
Not First Generation	8.4%	1,339	0.78
Pell Grant Recipient Status			
Pell Grant Receipt	15.4%*	2,239	1.04*
No Pell Grant Receipt	8.5%	1,369	0.83
Educational Opportunities Program			
EOP Eligible	19.2%*	1,930	1.13*
Not EOP Eligible	8.2%	1,678	0.78
Race			
Hispanic / Latino/a	19.3%[b]	1,468	1.11[b]
Asian	12.0%[c]	841	0.85[ac]
African American / Black	16.7%[b]	169	1.28[b]
White	7.8%[a]	988	0.77[ac]
Pacific Islander	10.9%[abcd]	12	0.51[abc]
American Indian / Alaskan Native	9.7%[ac]	35	0.89[abc]
International	11.4%[abc]	25	1.40[abc]
Unknown	4.5%[d]	70	1.08[abc]
All Students	**11.5%**	**3,608**	**0.96**

Statistically significant differences between groups at the .05 level, a-d Groups with the corresponding letter do not differ at the .05 level (i.e., groups who do not share a letter significantly differ).
Note: *Statistically significant differences between groups signify that there is a high probability that the difference between the means is not due to random chance.* _Population:_ *Students included in the second column are all undergraduate students who attended UCSC, excluding summer session, at all during any of the years between fall 2010 and spring 2014. Students included in the last two columns are the subset of students who attended at least one tutoring session.*

Significantly more women (14.9%) attended tutoring as compared to men (8.5%), and women utilized significantly more (1.02 sessions per quarter) than men (0.86). First generation college students were twice as likely to attended tutoring (16.8%) as compared to non-first generation college students (8.4%), and they attended at a higher rate (1.08 sessions per quarter compared to 0.78 sessions per quarter);

both differences were statistically significant. Pell Grant recipients were also significantly more likely to have attended tutoring (15.4%) and attended significantly more often (1.04 sessions per quarter) than their non-recipient peers, for whom 8.5% attended tutoring and at a rate of 0.83 sessions per quarter. EOP-eligible students' rates of tutoring (19.2%) were more than double that of EOP-ineligible students (8.2%) and the differences in rate of attendance were nearly as stark (1.13 session per quarter for EOP and 0.78 sessions per quarter for non-EOP); both differences were statistically significant. All differences between racial/ethnic groups are displayed in Exhibit 4, but the most notable differences were that Hispanic/Latino/a and African American/Black students were significantly more likely to utilize tutoring (19.3% and 16.7% respectively) and utilized at a significantly higher rate (1.11 and 1.28 sessions per quarter respectively) than White students (7.8% attended tutoring at a rate of 0.77 sessions per quarter).

The demographic characteristics of MSI and tutoring attendees were a reflection of the general campus demographics for these years (e.g., more White students than other racial/ethnic groups) but with a skew toward the differences in utilization heretofore outlined (e.g., Hispanic/Latino/a and African American/Black students were more likely to utilize LSS). All student and LSS attending student demographic characteristics are shown in Exhibit 5.

Exhibit 5: Demographic Characteristics of MSI and Tutoring Attendees Compared to All Students

Demographic Characteristics	All Students	Students who Attended MSI	Students who Attended Tutoring
Gender			
Women	52.7%	59.5%	66.2%
Men	47.3%	40.5%	33.8%
First Generation Status			
First Generation	44.4%	55.2%	61.5%
Not First Generation	55.6%	44.8%	38.5%
Pell Grant Recipient Status			
Pell Grant Receipt	47.4%	55.3%	62.1%
No Pell Grant Receipt	52.6%	44.7%	37.9%
Educational Opportunities Program			
EOP Eligible	32.8%	46.5%	53.5%
Not EOP Eligible	67.2%	53.5%	46.5%
Race			
Hispanic / Latino/a	24.9%	35.5%	40.7%
Asian	22.9%	27.6%	23.3%
African American / Black	3.3%	4.2%	4.7%
White	41.5%	28.8%	27.4%
Pacific Islander	0.4%	0.4%	0.3%
American Indian / Alaskan Native	1.2%	1.0%	1.0%
International	0.7%	1.0%	0.7%
Unknown	5.1%	1.0%	5.1%

Population: Students who attended MSI are all students who ever attended MSI. Students who attended tutoring are all students who ever attended tutoring.

No significance testing was conducted, but LSS appeared to serve a larger percentage of women, Pell Grant recipients, Latino/a students, and first generation college students. Notably, there were more EOP-eligible students than EOP-ineligible students attending tutoring but fewer EOP-eligible students than EOP-ineligible students attending MSI. This is the only instance where the preponderance of participation rates by demographic characteristic was different for MSI compared to tutoring.

Relationship between LSS Utilization and Course Grades

We assessed the relationship between LSS utilization and course grade, before and after controlling for demographic characteristics and high school GPA. All of the demographic characteristics used in these analyses, as well as high school GPA, could potentially be proxies for academic preparation. Controlling for these variables in the analysis allowed us to see the effect of LSS services after taking into account the fact that some students, because of differential levels of preparation they bring to the class, were likely to perform less well than others. These analyses have the added advantage of modeling a student's predicted grade point gains for each additional session attended.

Hierarchical linear regression was used to assess the relationship between MSI utilization and relative course grade. As shown in Exhibit 6, before controlling for demographic characteristics and high school GPA, MSI utilization appeared to be unrelated to relative course grade. When gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA were controlled for in the model, MSI utilization was a powerful positive predictor of relative course grade. Each additional session attended related to earning, on average, 0.02 grade points more than the class average.

Exhibit 6: Relationship between MSI Utilization and Course Performance

Predictors of Course Performance	Coefficient	Standard Error
Step 1		
MSI Utilization	0.04	0.03
Step 2		
MSI Utilization	0.20**	0.03
Gender	0.00	0.17
Hispanic / Latino/a	-0.22**	0.02
Asian	-0.07*	0.02
African American / Black	-0.27**	0.05
Pacific Islander	-0.02	0.12
American Indian / Alaskan Native	-0.21*	0.09
International	0.19*	0.09
Unknown	0.11	0.07
First Generation Status	-0.13**	0.02
Pell Grant	-0.01	0.02
EOP Eligible	-0.17**	0.02
High School GPA	0.70**	0.03

**Statistically significant relationships between predictors and course performance at the .001 level, *Statistically significant relationships between predictors and course performance at the .05 level.
<u>*Note*</u>*: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Regressions are OLS models where course performance is measured as the difference between the*

student's grade and the class average. Racial groups listed are in comparison to White students. <u>Population</u>: Population includes all students who were enrolled in at least one MSI supported course.

This suggests that MSI utilization was related to better academic performance than might otherwise be expected. Without MSI, the students who opted to use it would have performed less well, on average, but instead performed as well as students who did not use it. Furthermore, average gaps in course performance by race/ethnicity, and EOP and first generation status likely would have been greater without MSI.

Similar to MSI utilization, tutoring utilization was not initially related to relative course grade, but after controlling for demographic characteristics and high school GPA, tutoring positively predicted course performance, with each additional session of tutoring relating to an increase of 0.04 grade points above the class average (Exhibit 7). Hierarchical linear regression was used to assess the relationship between tutoring utilization and relative course grade. After including gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA as control variables in the model, tutoring utilization became a powerful positive predictor of relative course grade. This suggests that, like MSI, tutoring utilization was related to better academic performance, but because students who were already struggling in their coursework utilized tutoring more, the predicted positive effect was not apparent because of attendees' lower baseline performance.

Exhibit 7: Relationship between Tutoring Utilization and Course Performance

Predictors of Course Performance	Coefficient	Standard Error
Step 1		
Tutoring Utilization	-0.01	0.01
Step 2		
Tutoring Utilization	0.04**	0.01
Gender	0.05**	0.01
Hispanic / Latino/a	-0.17**	0.01
Asian	-0.07**	0.01
African American / Black	-0.21**	0.02
Pacific Islander	-0.04	0.06
American Indian / Alaskan Native	-0.08*	0.04
International	-0.05	0.05
Unknown	-0.03	0.02
First Generation Status	-0.09**	0.01
Pell Grant	-0.03*	0.01
EOP Eligible	-0.13**	0.01
High School GPA	0.47**	0.01

**Statistically significant relationships between predictors and course performance at the .001 level, *Statistically significant relationships between predictors and course performance at the .05 level.
<u>Note</u>: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Regressions are OLS models where course performance is measured as the difference between the student's grade and the class average. Racial groups listed are in comparison to White students. <u>Population</u>: Population includes all students who were enrolled at UCSC between fall 2010 and spring 2014, excluding summer session.

There are a number of confounding issues with these analyses because they compare the grades of students who utilized LSS at varying rates. It may be that the least prepared students used LSS and comparing them to more prepared students who do not was an unfair comparison. Even among students who were similarly prepared, those who sought LSS may have been more motivated to succeed or had some other underlying characteristic that might make them more or less likely to succeed in their courses. To overcome this problem, we next compared students against themselves: we analyzed students' grades in the courses where they utilized LSS and compared them to their grades when they did not utilize LSS (only including MSI supported courses when analyzing MSI). For both analyses, we measured course grade not in raw grade points earned but instead using relative course grade, which is the student's grade point difference from the course average. This indicates how much better or worse students did than everyone else in their class, and it has the added benefit of controlling for course difficulty, which may confound results.

Paired samples t-tests were conducted to assess differences in course performance (course grade and relative course grade) when a given student did and did not attend MSI and then again for tutoring. In this analysis, students were compared against themselves (when they did versus did not attend LSS), and as a result, only students who had both coursework where they did utilize LSS and did not utilize LSS can be included in these analyses (i.e., students who always or never utilized LSS are excluded).

Students' average course grade was higher in courses where they attended MSI compared to when they did not, but students' average course grade was lower in classes where they attended tutoring compared to classes where they did not attend tutoring. As shown in Exhibit 8, students earned 0.05 grade points above the class average when they attended MSI and 0.07[4] grade points below the average when they did not, and the difference is statistically significant. For tutoring, students typically earned 0.11 grade points below the average when attending tutoring and 0.02[3] points below the average when not attending tutoring; the difference is statistically significant.

Exhibit 8: Differences in Course Grade for Students Who Do or Do Not Attend MSI and Tutoring

Learning Support Services Attendance	Population Size	Course Grade Points	Relative Course Grade Points
MSI**	4,235		
Attending		2.66	0.05
Not Attending		2.56	-0.07
Tutoring**	3,455		
Attending		2.69	-0.11
Not Attending		3.03	-0.02

**Statistically significant differences between groups at the .001 level.
Note: Statistically significant differences between groups signify that there is a high probability that the difference between the means is not due to random chance. Population: MSI population includes all students who attended MSI in at least one course and did not attend MSI in at least one other course. Tutoring population includes all

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[4] Values for relative course grade do not add up to zero because MSI and tutoring utilizers are a subset of all students, who tend to, on average, do better or worse than all students at UCSC, from which relative course grade is calculated.

students who attended tutoring in at least one course and did not attend tutoring in at least one other course. These populations were chosen in order to compare students' performance when using and not using LSS.

These findings support previous findings from LSS's self-assessment research, but they have the added benefit of minimizing selection bias because students were compared against themselves instead of each other. Not only did students who utilized MSI perform better than their peers, these students also performed better in classes where they attended MSI as compared to the classes where they did not.

For tutoring, the picture is more complex: regression analyses suggest that increasing tutoring sessions attended increased grades, but when students were compared to themselves, they did worse in the classes where they attended tutoring in comparison to classes where they did not. Because these analyses looked at total number of sessions attended and prior analyses shown in Exhibit 7 compared students when they attended at all versus those who did not attend, the potential positive outcomes of tutoring may only appear after several sessions of attendance. Alternatively, students who utilized tutoring might be more motivated than the average student, so when they are compared to others—as in Exhibit 7—tutoring may appear efficacious, but these students may only have utilized tutoring in the classes in which they personally struggled and thus earned lower grades in those classes. MSI may be seen more as a whole-class activity in which many student participate, but signing up for tutoring requires more effort and potentially self-identifying as struggling. Finally, for a variety of reasons, tutoring may be a less effective program than MSI at raising course grades.

Retention Rate

Retention is a key concern, particularly for underrepresented minority and other at-risk students, so assessing potential benefits of LSS beyond course performance is important. We examined the role of MSI utilization on students' retention from freshman to sophomore (for the 2010, 2011, and 2012 cohorts), junior (for the 2010 and 2011 cohorts), and senior (for the 2010 cohort) years, and then all years combined for total retention rate. All years were combined in order to maximize population size, in large part because the populations, when broken down in this manner, are relatively small. We then analyzed the relationship between retention and tutoring utilization, with retention broken down in the same manner for the same cohorts.

As shown in Exhibit 9, MSI utilization was not significantly related to sophomore, junior, senior, or total retention rate. Separate binary logistic regressions were used to analyze the relationship between MSI utilization and odds of being retained to one's sophomore year, junior year, senior year, or at all. All regressions controlled for gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA. MSI did not significantly predict freshman, sophomore or junior retention rate or the rate overall across all groups.

These findings provide no support for MSI increasing or decreasing one's odds of staying at UCSC. Although analyses controlled for a number of factors that affect retention, it is impossible to control for all of the factors that may contribute to lower retention rates (e.g., feeling academically unsuited for one's major). It may be that MSI utilization compensates for uncontrolled variables that would

otherwise lead to worse retention among this population. Because academic performance is a known predictor of retention, and MSI utilization is related to improved academic performance, this finding is somewhat counterintuitive. However, academic success is a necessary but not sufficient predictor of retention and MSI is only one small part of academic success.

Exhibit 9: Relationship between MSI Utilization and Retention Rate

MSI Utilization Predicting Retention to Various Years	Predicted Effect of MSI on Retention	Standard Error	Population Size
Sophomore Retention	0.25	0.26	7,059
Junior Retention	-0.11	0.30	3,790
Senior Retention	0.27	0.77	1,425
Total Retention	0.22	0.21	7,059

No coefficients are statistically significant at the .05 level. Each predictor represents a separately computed regression. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.

Note: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Binary logistic regressions are odds ratios where a number greater than 0 indicates increased odds of being retained whereas a number less than 0 indicates decreased odds. Population: For all retention populations, only students who enrolled in at least one MSI supported course are included. Sophomore retention population is made up of those students who were enrolled as new freshman in fall 2010, 2011, or 2012. Junior retention population is made up of those students who were enrolled as new freshman in fall 2010 or 2011 and were retained to their sophomore year. Senior retention population is made up of those students who were enrolled as new freshman in fall 2010 and were retained to their junior year. Total retention population is made up of all students who were enrolled as new freshman in fall 2010, 2011, or 2012.

Unlike MSI utilization, tutoring utilization was a powerful, positive predictor of retention to all years: sophomore year, junior year, and all years combined. Separate binary logistic regressions were used to analyze the relationship between tutoring utilization and odds of being retained to one's sophomore year, junior year, senior year, or at all. These regressions all controlled for gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA. As shown in Exhibit 10, tutoring utilization positively predicted retention to sophomore year, a very large effect size. For junior and senior retention rate, tutoring utilization also significantly predicted odds of being retained, but not to the same large degree. Finally, tutoring utilization powerfully and positively predicted total retention.

Taken together, these findings suggest that students who utilized tutoring were much more likely than their peers to be retained at UCSC. Looking at the freshman dropout cohorts (2010-11, 2011-12, and 2012-13) for example, tutoring attendees comprised 24.5% of the students in the population, but they only made up 0.4% of dropouts; this means students who attended tutoring generally did not drop out. This may be because students who chose tutoring were more academically motivated to overcome challenges in school, evidenced by their drive to attend tutoring. Additionally, tutoring may have helped students overcome their toughest classes, keeping them in their programs.

Exhibit 10: Relationship between Tutoring Utilization and Retention Rate

Tutoring Utilization Predicting Retention to Various Years	Predicted Effect of Tutoring on Retention	Standard Error	Population Size
Sophomore Retention	4.60*	0.48	10,046
Junior Retention	1.68*	0.24	5,800
Senior Retention	3.87*	1.01	2,439
Total Retention	3.70*	0.30	10,046

*Statistically significant relationships between tutoring utilization and retention rate at the .001 level. Each predictor represents a separately computed regression. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.
<u>*Note*</u>*: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Binary logistic regressions are odds ratios where a number greater than 0 indicates increased odds of being retained whereas a number less than 0 indicates decreased odds.* <u>*Population*</u>*: Sophomore retention population is made up of those students who were enrolled as new freshman in fall 2010, 2011, or 2012. Junior retention population is made up of those students who were enrolled as new freshman in fall 2010 or 2011 and were retained to their sophomore year. Senior retention population is made up of those students who were enrolled as new freshman in fall 2010 and were retained to their junior year. Total retention population is made up of all students who were enrolled as new freshman in fall 2010, 2011, or 2012.*

Graduation Rate

Like retention rate, on-time graduation is a key goal of UCSC and the role of LSS in helping students achieve this goal is important to understand. With available data, we could only assess four-year graduation for a single cohort. These findings, although still useful, are inherently limited by the small set of students and the fact that a large percentage of UCSC students take more than four years to graduate. These findings should not be interpreted as students' odds of graduating at all because many of the students who do not graduate in four years will do so within five or six. Binary logistic regression was used to assess the relationship between LSS utilization and odds of graduating in four years.

MSI utilization was not a significant predictor of four-year graduation but tutoring utilization was, although in a direction counter than expected. As shown in Exhibit 11, for the fall 2010 cohort, MSI utilization did not significantly predict odds of graduating within four years when controlling for gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA.

Exhibit 11: Relationship between MSI or Tutoring Utilization and Four-Year Graduation Rate

Utilization Predicting Graduation	Predicted Effect of Utilization on Four-Year Graduation	Standard Error	Population Size
MSI Utilization	0.07	0.20	1,465
Tutoring Utilization	-0.17*	0.06	2,986

*Statistically significant relationships between utilization and 4-year graduation rate at the .01 level. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.
<u>*Note*</u>*: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Binary logistic regressions are odds ratios where a number greater than 0 indicates increased odds of being retained whereas a number less than 0 indicates decreased odds.* <u>*Population*</u>*: MSI population includes all students in the 2010 fall cohort who were enrolled in at least one MSI supported course. Tutoring population includes all students in the 2010 fall cohort.*

Tutoring utilization, with this same cohort, significantly predicted odds of graduating when controlling for the same variables as the previous analysis, but the relationship was negative, with higher tutoring utilization rates relating to lower odds of graduating within four years.

For MSI, these findings suggest that although attending MSI sessions may have improved one's course grade, improvements did not appear to translate to a more timely graduation. For tutoring, these findings suggest that although attending tutoring sessions was related to being retained at UCSC, these students may not graduate on time. For both, we do not know if LSS utilization was related to graduating at all, although we can infer from retention findings that tutoring may predict increased odds of eventual graduation.

MSI in Biology

Biology is popular on campus, with several majors involving a heavy biology component, the most notable of which are the general Biology B.S., Ecology and Evolution, and Molecular Cell and Developmental Biology. A large percentage of the students enrolled at UCSC during the four years of data collected (26.3%) declared some biology related major. Thus, understanding the role of MSI utilization within the introductory courses of this major and on declaration of a biology major is important. An array of courses were identified by LSS and biology department as foundational for students' success in any one of the majors and supported by MSI: College Algebra for Calculus (MATH002), Precalculus (MATH003), Calculus with Applications A (MATH011A), Calculus with Applications B (MATH011B), Calculus for Science, Engineering, or Mathematics A (MATH019A), Calculus for Science, Engineering, or Mathematics B (MATH019B), Cell And Molecular Biology (BIOL020A), Development And Physiology (BIOE020B), General Chemistry A (CHEM001A), General Chemistry B (CHEM001B), and General Chemistry C (CHEM001C). For each of these courses, we first analyzed the relationship between MSI attendance and course performance among all students. Next, we analyzed the relationship between MSI attendance within these courses (separately and combined) and eventual major declaration among prospective biology majors. For a student to be considered a prospective biology major, they had to have: 1) enrolled in any one of the general biology courses (BIOL020A, BIOE020B, BIOE020C); and 2) enrolled in any one of the general chemistry courses (CHEM001A, CHEM001B, CHEM001C).

MSI attendance was positively related to course performance in BIOL020A, BIOE020B, and CHEM001B; negatively related to course performance in MATH002; and not significantly related to course performance within any of the other classes. Separate hierarchical linear regressions were used to analyze the relationship between MSI session attendance and relative course grade after controlling for demographic characteristics (gender, race/ethnicity, Pell Grant, first generation status, EOP) and high school GPA. Exhibit 12 shows the relationship between MSI utilization and relative course grade for all classes in the biology sequence.

MSI session attendance significantly predicted relative course grade in BIOL020A, with an increase of one MSI session relating to a 0.03 higher grade point than one's peers. Similarly, MSI attendance in

BIOE020B significantly related to a 0.04 increase in grade points per session, so an estimated 0.36 increased grade point above one's peers when attending nine sessions. In CHEM001B, MSI session attendance also predicted an increase in relative course performance, with attendance at an additional session predicting a 0.03 increase in grade points.

Exhibit 12: Relationship between MSI Utilization and Course Performance in Biology

MSI Attendance Predicting Relative Course Performance in Various Classes	Predicted Effect of MSI on Performance	Standard Error	Population Size
College Algebra for Calculus	-0.02*	0.01	1,536
Precalculus	0.00	0.00	5,314
Calculus with Applications A	0.02	0.01	3,571
Calculus with Applications B	0.01	0.01	2,985
Calculus for Science, Engineering, or Mathematics A	0.01	0.02	2,458
Calculus for Science, Engineering, or Mathematics B	0.00	0.02	2,708
Cell And Molecular Biology	0.03*	0.01	3,311
Development And Physiology	0.04*	0.01	2,819
General Chemistry A	0.01	0.01	5,420
General Chemistry B	0.03*	0.01	4,204
General Chemistry C	0.00	0.01	3,922

Statistically significant relationships between attendance and relative course performance at the .01. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.

Note: *Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Regressions are OLS models where course performance is measured as the difference between the student's grade and the class average.* Population: *Population for each class includes all students who enrolled in said class during the regular academic year.*

MSI attendance in MATH002, however, appeared to relate to a decrease in course performance relative to one's peers: each additional session attended related to 0.02 grade points lower. For all other classes (MATH003, MATH011A, MATH011B, MATH019A, MATH019B, CHEM001A, CHEM001C), there was no statistically significant relationship between MSI session attendance and course performance. These findings add complexity to the data showing that MSI utilization related to improved course performance because there does not seem to be a relationship between MSI attendance and improved grades for a number of important courses, and the relationship was negative for MATH002, a particularly foundational course—but also one that has historically had challenges at UCSC.[5] These mixed findings warrant investigating what is working with MSI in some courses and not in others. As with all findings presented here, it is impossible to determine whether the increases or reductions associated with LSS attendance are entirely due to the programs efficacy, the particular challenges of the course material (e.g., reliance on fundamental knowledge from previous coursework), or the

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[5] MATH002 has been supported through LSS in a number of ways over these years, with one- and two-week versions, voluntary and compulsory signups, and different populations leading sections. These changes are in part an attempt to resolve the lower than ideal pass rates in MATH002. Part of why MATH002 is a challenge at UCSC is because the students who test into it are likely those who struggle the most with math and thus need to take this high school level algebra class while in college.

individual characteristics of students who choose to seek out LSS, although several individual characteristics are controlled for in these analyses.

There was no statistically significant relationship between MSI session attendance and any biology major declaration. Separate binary logistic regressions were used to analyze the predicted effect of MSI utilization in MATH002, MATH003, MATH011A, MATH011B, MATH019A, MATH019B, BIOL020A, BIOE020B, CHEM001A, CHEM001B, CHEM001C, and all eleven courses combined on odds of declaring a biology major after controlling for gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA. As shown in Exhibit 13, MSI session attendance in the early biology major sequence did not relate to eventual major declaration. Even in BIOL020A, BIOE020B, and CHEM001B, where MSI attendance related to increased grades, there was no significant relationship between session attendance and major declaration. These findings suggest that any potential benefits of MSI on course performance did not appear to translate to declaring a biology major. This may be due to our imperfect criteria for determining a prospective major, inability to remove students who left the major for reasons other than poor performance, and MSI not being efficacious when it comes to long-term improvements in the major as a whole.

Exhibit 13: Relationship between MSI Attendance and Any Biology Major Declaration

MSI Attendance Predicting Major Declaration	Predicted Effect of MSI on Declaration	Standard Error	Population Size
College Algebra for Calculus	-0.04	0.05	278
Precalculus	-0.04*	0.02	1,419
Calculus with Applications A	-0.03	0.05	2,051
Calculus with Applications B	0.02	0.05	2,136
Calculus for Science, Engineering, or Mathematics A	-0.27	0.18	516
Calculus for Science, Engineering, or Mathematics B	0.24	0.22	629
Cell And Molecular Biology	0.01	0.02	3,136
Development And Physiology	0.05	0.03	2,465
General Chemistry A	-0.04	0.03	3,277
General Chemistry B	-0.05	0.02	3,151
General Chemistry C	-0.01	0.02	3,263
All Biology Courses Combined	0.00	0.04	3,711

No coefficients are statistically significant at the .05 level. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.
<u>Note</u>: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Binary logistic regressions are odds ratios where a number greater than 0 indicates increased odds of being retained whereas a number less than 0 indicates decreased odds. <u>Population</u>: Population for each class includes all students who enrolled in said class and also one of the introductory biology courses (BIOL020A, BIOE020B, BIOE020C) and one of the introductory chemistry courses (CHEM001A, CHEM001B, CHEM001C).

MSI in Psychology
Psychology is one of the largest majors on campus, with 11.6% of all students enrolled during 2010-14 having declared a psychology major. Considering the popularity of this major, understanding the role of MSI utilization within specific, key classes in the major and on declaration of a psychology major is

important. Introduction to Psychology (PSYCH001), Introduction to Psychology Statistics (PSYCH002), and Introduction to Statistics (AMS005)—an alternative to PSYCH002—were identified by both LSS and psychology department staff as critical courses that students struggle in, are necessary for declaring a psychology major, and for which MSI is offered. Thus, we first analyzed the relationship between MSI attendance and course performance in these classes among all students. Then, we analyzed the relationship between MSI attendance within these courses (separately and combined) and eventual major declaration among prospective psychology majors. Because the data available to us did not include information about whether a student intended to declare a psychology major, we used the students' course history to estimate this; this estimation criterion is admittedly imperfect. Enrollment in PSYCH001 was used to approximate intent to declare a psychology major.

MSI attendance was positively related to course performance in all three classes analyzed, with an increase in attendance of one session relating to 0.02 (PSYCH002) or 0.03 (PSYCH001 or AMS005) more grade points above the class average. Separate hierarchical linear regressions were used to analyze the relationship between MSI session attendance and relative course grade after controlling for demographic characteristics (gender, race/ethnicity, Pell Grant, first generation status, EOP) and high school GPA.

As shown in Exhibit 14, MSI session attendance significantly predicted relative course grade in PSYCH001, with students who took a full MSI load (9 sessions attended) earning an estimated 0.27 higher grade point than their peers. In PSYCH002, the relationship between MSI session attendance and course performance was marginally significant,[6] with MSI session attendance predicting a smaller grade point increase than PSYCH001. Finally, MSI attendance in AMS005, like PSYCH001, positively predicted relative course grade, with each additional session attended relating to a 0.03 grade point increase above one's peers.

Exhibit 14: Relationship between MSI Utilization and Course Performance in Psychology

MSI Attendance Predicting Relative Course Performance in Various Classes	Predicted Effect of MSI on Performance	Standard Error	Population Size
Introduction to Psychology	0.03*	0.01	3,149
Psychology Statistics	0.02†	0.01	1,050
Introduction to Statistics	0.03*	0.01	3,010

Statistically significant relationships between attendance and relative course performance at the .01, †Statistically significant relationships between attendance and relative course performance at the .01, level. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.
Note: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Regressions are OLS models where course performance is measured as the difference between the student's grade and the class average. Population: Population for each class includes all students who enrolled in said class during the regular academic year.

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[5] An effect is considered marginally significant when the probability of the relationship being due to chance is less than 10%, as opposed to the more conservative and widely accepted convention of 5%.

These findings mirror the general findings for MSI utilization, showing that MSI appears to be efficacious. Additionally, they show that the positive relationship between MSI and course performance was maintained in some of the more difficult and essential courses. PSYCH001 and PSYCH002 are gate-keeping courses, wherein earning a grade lower than a B- prevents one from entering the major, so increased grade points in these classes specifically is particularly important for students who wish to declare a psychology major.

There was no statistically significant relationship between MSI session attendance and psychology major declaration. Separate binary logistic regressions were used to analyze the predicted effect of MSI utilization in PSYCH001, PSYCH002, AMS005, and introduction to psychology and statistics combined on odds of declaring a psychology major after controlling for gender, race/ethnicity, Pell Grant, first generation status, EOP, and high school GPA. As shown in Exhibit 15, the relationship between MSI session attendance in PSYCH001 and odds of declaring a psychology major was small and not statistically significant, suggesting no relationship. For PSYCH002, the relationship was also not statistically significant but slightly larger than PSYCH001. MSI session attendance in AMS005 also did not significantly predict major declaration. Even when combining attendance across introduction to psychology and either statistics course, the relationship between MSI session attendance and major declaration was not statistically significant. These findings suggest that MSI session attendance may help students perform better in their classes, but this predicted boost may not carry over to successful major declaration. Additionally, we do not have data for why a student did not declare a psychology major, so students who were never intending a psychology major or changed their intended major for reasons other than poor course performance may be washing out the effect. There is no way of precisely identifying those students who wish to become psychology majors, especially because many of the courses that could identify a potential psychology major are available as AP classes in high school (i.e., introduction to psychology and statistics). These findings are interesting but further analyses will need to be conducted before claiming anything conclusive.

Exhibit 15: Relationship between MSI Attendance and Psychology Major Declaration

MSI Attendance Predicting Major Declaration	Predicted Effect of MSI on Declaration	Standard Error	Population Size
Introduction to Psychology	-0.01	0.02	3,150
Psychology Statistics	-0.05	0.03	747
Introduction to Statistics	0.03	0.04	749
Intro to Psychology and Statistics Combined	-0.07	0.08	3,150

No coefficients are statistically significant at the .05 level. Regressions were calculated controlling for gender, race/ethnicity, first generation status, Pell Grant recipient status, EOP Status, and high school GPA.
Note: Statistically significant relationships signify that there is a high probability that the correlation is not due to random chance. Binary logistic regressions are odds ratios where a number greater than 0 indicates increased odds of being retained whereas a number less than 0 indicates decreased odds. Population: Population for each class includes all students who enrolled in said class and also PSYCH001.

Discussion

This study analyzed four years of student data from fall 2010 to spring 2014. During these years, one-fifth of all enrolled students attended MSI and slightly more than one-tenth attended tutoring. Focusing specifically on students who entered UCSC in fall 2010 and stayed enrolled for four years to 2014, 22% attended MSI at least once during the four subsequent years. However, 40% of these students never enrolled in a course that offered MSI and 38% enrolled in an MSI-supported course, but did not make use of the program. In the same group, one-third of students attended at least one tutoring session over the subsequent four years.

For both MSI and tutoring, historically underserved demographic groups were more likely to have ever attended and generally attended more sessions. Higher-utilizing students of both MSI and tutoring tended to get better grades than their lower-utilizing peers. Students who sometimes utilized LSS earned better grades in the classes where they attended MSI but lower grades in the classes where they attended tutoring. MSI attendance did not appear to directly predict retention and graduation, but tutoring attendance related to increased retention. In biology majors, MSI attendance was efficacious in some of the fundamental biology and chemistry subject courses, but not in the required math classes. In the psychology major, MSI attendance appeared to be beneficial in both statistics and the introductory psychology subject course. For both majors, MSI attendance did not appear to effect eventual major declaration.

Looking at all findings together, there are several clear themes. LSS reached a substantial percentage of the undergraduate population, with significant overreach of students who historically have more challenges in college. LSS thus appeared to be addressing educational equity by overserving the demographic groups who have historically been underserved.

MSI's relationship with course performance was a mostly clear picture, with increased attendance relating to increased performance, although there was some variation from course to course. Tutoring was more complex because higher utilizing students performed better than lower utilizing students, but those students who utilized tutoring performed worse in the classes in which they attended tutoring. Given that tutoring is likely only utilized in the courses that students find most challenging for them, this relationship might not be contradictory: tutoring generally helped students in their coursework, but the classes for which students chose to use tutoring were the hardest classes that they took and thus their grades were lower in them.

The benefits of MSI did not appear to relate to increased retention or timely graduation. Success in one's coursework is fundamental for retention and timely graduation, so further research into this inconsistency is warranted. Tutoring, however, was related to increased retention, so it may be that these more individualized, small-group sessions have a more powerful impact on students, both in their challenging benchmark courses and in the aggregate.

Finally, analyses of specific courses in the biology and psychology majors suggests that there is variation in terms of MSI's efficacy in different courses, with subject courses more often having positive relationships than basic math courses. Differences in courses might be due to differences between class format, course content, instructor buy-in, or the student population. At the very least, these differences warrant comparing the different courses in order to identify best practices and places for improvement.

Although there are many informative findings, this study has at least two limitations. Four years of data is already a large amount, but if LSS attendance records were comprehensively collected and matched to other administrative data for a larger length of time, five- and six-year graduation and retention could be analyzed. Secondly, this analysis is an attempt to look broadly at MSI and tutoring in general to answer the question of whether or not these programs are efficacious, and some nuance vis a vis learning assistant experience, instructor variation, and granular course difference are inherently lost when attempting to answer big picture questions. We intend for this report to be a backdrop in which other, smaller analyses can be grounded.

LSS has several previous and forthcoming analyses that support and add detail to the findings presented here. Previous analyses have found that MSI attendees perform better in a chemistry course, but these gains were not enough to erase differences between EOP-eligible and EOP-ineligible students. Forthcoming analyses are assessing a wider array of courses and integrating hypothesis testing for statistical significance. These analyses will add some of the nuance and detail that this study lacks. We hope that this study will provide general trends from which the more specific analyses can be compared.

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