Supplemental Instruction: Helping Disadvantaged Students Reduce Performance Gap

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Abstract

This study examined how Supplemental Instruction (SI) visits help traditionally disadvantaged students reduce the performance gap in their courses. A student is defined as holding a "disadvantaged" status when he or she can identify with the following factors: underrepresented minority status, first-generation status, Federal Pell Grant eligible status, and English/Mathematics remedial status. This study revealed that students including both disadvantaged and non-disadvantaged students would benefit more from more SI participation. Furthermore, the more disadvantaged students gained larger performance improvement than less disadvantaged students with more SI visits and the performance gap closed at 16 SI visits, indicating the importance of regular SI participation for disadvantaged students to close the performance gap with non-disadvantaged students.

Key words

Supplemental Instruction

Disadvantaged students

Underrepresented minority students

First-generation students

Performance gap

Achievement Gap

SI visits

At a glance, the educational system within the United States seems to be making strong strides to improve student access, retention, and persistence (Engle & Tinto, 2008). Upon closer examination however, one sees wide gaps in equality of the degree attainment in higher education, especially for students considered as disadvantaged with characteristics such as being a first-generation college student, requiring English and math remediation, from a low-income household, and identifying with an underrepresented minority (URM) ethnic group. This particular student population has encountered severe academic challenges resulting in a much lower performance and achievement rate than their counterparts.

According to the US Department of Education (2013), in 2009-2010, roughly 10 percent of African American students and 9 percent of Hispanic students earned a bachelor's degree, which is only slightly up from the 1999-2000 figures of 9 and 6 percent respectively. This stands in sharp contrast to the 72.9% of White students who have earned a four-year degree. In other words, White students are roughly seven times more likely to graduate with a bachelor's degree than their URM peers. A similar situation is found with respect to socioeconomic status, where the gap in achieving a four-year degree between low- and high-income students nearly doubled in the last 35 years (Engle & Tinto, 2008). Generally, then, wide and widening gaps exist across ethnic and income lines.

Engle and Tinto (2008) described the path to successful completion of a bachelor's degree for most of the 4.5 million low-income, first-generation students enrolled in postsecondary education as "long, indirect, and uncertain" (p. 2). Across all institution types, low-income, first-generation students were nearly four times more likely to leave higher education after the first year when compared to students who did not have similar risk factors

(Engle & Tinto, 2008). Such statistical evidence demonstrates the importance for educational institutions to understand the needs of their disadvantaged student population and to implement successful interventions to reduce the existing performance and achievement gaps.

Limitations of Current Studies on SI

SI is a high-impact practice originally developed by Dr. Deanna Martin at the University of Missouri-Kansas City (UMKC) in 1973 and proven to increase academic performance and retention for students enrolled in traditionally difficult courses (Martin & Arendale, 1994). SI was recognized as an Exemplary Educational Program by the U.S. Department of Education and is unique in that it focuses on high-risk courses, rather than at-risk students, and is driven by a higher level of critical thinking skills (McGuire, 2006). The International Center for SI at UMKC defines SI as a collaborative learning approach program that utilizes peer-assisted study sessions in which a student leader facilitates regularly scheduled sessions to enhance course content, develop study skills, and compare notes.

There are limitations within the existing studies on SI. First, given SI mainly focuses on traditionally high-risk courses rather than at-risk students, there are limited studies on how SI affects the performance of at-risk students. Secondly, there are limited studies which explore how student performance is impacted by an increasing number of SI visits as there is no consistent operational definition of an SI participant. Many studies refer to SI participants after only one visit, but studies that look at visit correlation to student success could not be located.

In this study, we attempt to expand SI research by examining the relationship between the number of SI visits and course performance. Particularly, this study will examine whether and how the number of SI visits impact student course performance in terms of final course grade. The purpose of this study is to answer the following two questions: How does the number of SI

visits affect students' course performance and how do SI visits help traditionally disadvantaged students reduce the performance gap?

Literature Review

A traditionally disadvantaged student is known to identify with any one of four characteristics: URM status, first-generation student (FGS) status, Federal Pell Grant eligible status, and English/mathematics remedial status. These students are less likely to accomplish their educational goals due to lack of access, familial and/or peer support, or feelings of exclusion (Beal & Noel, 1980; Webb, 1987; Chaney, Muraskin, Cahalan & Goodwin, 1988).

URM students are those designated as "students of color" or who are sometimes referred to as "non-white." Typically, URM students include those who identify as Hispanic or Latino/a, African-American or Black, or Native American. Carter (2006) indicated ethnic minority students have a lower rate of completing their educational goals than their peers. They are less likely to be engaged in academic and social experiences, interact with faculty and other students, participate in extracurricular activities, and use social support services. Furthermore, this student population is more likely to live and work off-campus, to work full-time and take classes part-time (Engle & Tinto, 2008).

There are three definitions of a first-generation college student, all related to the parents' educational background: those whose parents have no college experience (McConnell, 2000; National Center for Educational Statistics [NCES], 1998; Riehl, 1994; Terenzini, Springer, Yaeger, Pascarella & Nora, 1996), those whose parents have not earned a two-year college degree, and those whose parents have not earned a four-year or bachelor's degree (Supiano, 2014). When compared to their continued-generation peers, first generation college students typically have a difficult time adjusting to the demands of their academic and personal lives,

have lower expectations of themselves, and lack in family support (both financially and emotionally) (McConnell, 2000; Terenzini et al., 1996; Darling & Smith, 2007; Engle & Tinto, 2008).

Students become eligible to receive funding for college through the Pell Grant program from the U.S. Department of Education based off their financial need, which is the difference between cost of attendance and expected family contribution. Most commonly, these students lack access to the technology used in learning and assessment, especially within competency-based assessment. They may also lack access to learning experiences outside of the traditional classroom (Lewis, Eden, Garber, Rudnick Santibanez, & Tsai, 2014).

Finally, students needing remediation lack the basic reading, writing, and quantitative reasoning skills required for success in college (Scott-Clayton, Crosta & Belfield, 2014). Although these students are accepted into college, they may be conditionally admitted until remedial courses are completed, or must complete the basic skills course in order to continue collegiate courses. Research has shown as students' average 2.6 courses to complete remediation, their time to degree completion is consequently extended (NCES, 2012).

Achievement Gap

The achievement gap has been defined in many ways within the scope of student performance. Depending on how it is defined, it can serve as a vital tool for improving our educational system. Shannon and Bylsma (2002) defined the achievement gap as "the difference between how a group performs compared to what is expected of it" (p. 11). Another study referred to the achievement gap as the difference in test scores between various demographic groups (Anderson, Medrich & Fowler, 2007). Compared to the various definitions, this research

focuses on the gap which exists between disadvantaged and non-disadvantaged students and their mean final course grade in a course supported with SI.

There are two major factors which contribute to the achievement gap: factors outside of the educational environment and factors within the educational environment (Shannon & Bylsma, 2002). Their report stated that outside factors such as socioeconomic status, family background, and student aspiration and personality impact the achievement gap. Educational factors such as limited access to equal education and recourses as well as lower-quality teaching are also major influences (Noguera, 2001; Shannon & Bylsma, 2002). Shannon and Bylsma (2002) also reported that learning opportunities such as extended learning time, rigorous curriculum, and participation in enriched and varied programs can help close the gap. Furthermore, learning opportunities increase time on tasks, challenge students' academic abilities, and promote a sense of belonging (Shannon & Bylsma, 2002).

A Framework of Student Success

Several studies have measured the impact of SI in higher education. It has repeatedly been shown to improve students' academic performance, such as course grade and retention (Congos & Schoeps, 1993, 1998; Lewis, O'Brien, Rogan & Shorten, 2005; Bowles & Jones, 2004; McGuire, 2006), and even graduation (Bowles, McCoy & Bates, 2008). The Geometric Model of Student Persistence and Achievement (Swail, 2004) has been used to explain the success of SI by placing the student directly in the center of a triangle, while identifying each side with a factor that is believed to impact student success. This particular model allows educators to explore the relationship between cognitive, social, and institutional factors.

As identified by Swail (2004), cognitive factors such as intelligence, knowledge, and academic ability are crucial to student persistence and performance, as they directly impact the

student's ability to comprehend and successfully complete the academic demands of a college curriculum. Research found low-income, first-generation college students are more likely to take remedial courses, less likely to have access to or participate in a demanding high school curriculum, and as a consequence lack study and time management skills (Engle & Tinto, 2008).

On the other hand, disadvantaged students are less likely to engage in academic and social experiences such as studying in groups with peers, interacting with faculty members, participating in extracurricular activities, and using support services – all factors which nurture success in college (Engle & Tinto, 2008). Lehmann (2007) investigated the role played by a detached university culture within the increasing dropout rates among first-generation college students. Key findings suggested that first-generation students were more likely to leave college before accomplishing their educational goals, often despite having good academic standing, due to feeling disconnected with the college life, environment and culture. This lack in sense of belonging was identified more than any other reason of leaving their college career (Lehmann, 2007).

The third factor identified by Swail (2004), is institutional. This refers to the intended or unintended practices, strategies and culture of the college or university which impact student persistence and achievement. The institutional portion of this model speaks to the abilities of the institution to provide appropriate support to students through their college experience, both academically and socially. When an institution is unable to provide such support, it can interfere with student success. Rendon (1995) described many educational institutions as "not setup to educate or accommodate for diversity, creating an invalidating environment for students who do not 'fit the mold' " (p. 9), which often speaks to the experience of disadvantaged students within higher education.

When closely examining SI, one will find that the program includes each factor identified by the Geometric Model of Student Persistence and Achievement. SI is an institutional service that aims to enhance content knowledge and understanding. SI Sessions are embedded within an environment enriched with student engagement and participation. As structured study sessions are facilitated for individual courses, students are constantly surrounded by familiar faces. Through this promotion of student-to-student interaction, SI sessions hold the potential of providing students with a sense of belonging and contentedness with the university.

Data and Methods

This study included 16,297 undergraduate students enrolled in 22 courses supported by SI sessions (referred to hereafter as "SI courses") in six semesters from Fall 2011 to Spring 2014, drawn from a large state university in California. Among the 22 SI courses, 18 were STEM courses across five disciplines of Biology (N=7,866), Chemistry (N=581), Mathematics (N=3,713), Engineering (N=172), and Physics (N=1,109); and 4 were non-STEM courses across three disciplines of Criminology (N=105), Economics (N=361), and Political Science (N=2,390). 19 courses were lower division courses (N=16,184), and 3 were upper division courses (N=113). 10 were GE courses (N=12,296), and 12 were non-GE courses (N=4,001).

Among the 16,297 undergraduate students, 56.6% were female, and 66.2% were URM including African American (4.2%), American Indian (0.3%), Pacific Islander (0.3%), Hispanic (41.9%), and Asian (19.5%). Asian students are considered URM in our data because half of the Asian students are Hmong, an educationally underrepresented ethnic group. Most of the other Asians are non-Hmong Southeast Asians, bearing similar characteristics with Hmong students. About 66.8% of the students are first-generation college students, 60.6% are Pell Grant eligible, and 51.5% need remediation in math and/or English at entry. The majority of these students are

lower division students (38.7% freshmen, 26.8% sophomores, 17.9% juniors, and 16.6% seniors), 93.7% are full-time students, and 44.0% are in STEM majors.

In sum, our sampled data well represented the diverse student population within the university, as well as the diversity of courses offered, with one exception: There were only a few upper division courses supported by SI sessions, which reflects the fact that SI is mainly for high-risk courses in lower division but not in upper division at this institution.

Variables

The dependent variable in the study is SI course grades. All categorical course grades are converted to numerical grades (A=4, B=3, C=2, D=1 and F/WU=0). Independent variables of interest include both SI visits and students' disadvantaged status. SI visits are the total number of SI sessions and/or SI office hours a student attended during a semester. Student disadvantaged status is defined by four factors: URM status (URM vs. Non-URM), FGS status (FGS vs. Non-FGS), Pell eligible status (Pell eligible vs. Non-eligible), and Remedial status (Rem vs. Non-Rem).

Eight additional independent variables considered as controlling variables include five student characteristics (prior SI course performance, gender, student class level, full-time status, and major of college) and three course characteristics (discipline category (STEM vs. non-STEM), course level (LD vs. UD), and course type (GE vs. non-GE). Prior SI course performance is defined as the cumulative GPA at the beginning of the term in which a student took an SI course. For new freshmen (N=1,566) and transfer students (N=422) without a university cumulative GPA, high school GPA and transfer GPA have been used instead.

Purpose of the Study

The purpose of this study is to answer the following two questions: how SI visits affect students' course performance and how SI visits help traditionally disadvantaged students reduce the performance gap in SI courses. We would link the findings to the SI attendance pattern and examine under which specific conditions SI attendance may reduce or close the course performance gap.

Methods

This study employed multiple research approaches including both of data visualization and statistical modeling. We first ran scatter plots with the best fitted trend lines to describe the relationship between SI visits and course performance, and how the performance gap between disadvantaged and non-disadvantaged students is affected by number of SI visits. We then employed the General Linear Model (GLM) to determine the significant effects of SI visits on course performance after controlling other student and course characteristics.

GLM is a flexible statistical model which allows us to model the value of a quantitative dependent variable (such as course grades) based on its relationship to a set of independent variables (Horton, 1978; Leech, Barrett & Morgan, 2014). It can estimate the dependent variable with categorical independent variables as factors (such as disadvantaged status) or continuous independent variables as covariates (such as SI visits). Additionally, it allows us to specify factor-covariate interactions (such as the interaction of disadvantaged status and SI visits) to see if the relationship between a covariate and the dependent variable changes for different levels of factors.

Findings

Describing SI Visits, Disadvantaged Status and Performance Gap

In the following section, we would demonstrate the relationship between SI visits and course performance and determine the significant differences between disadvantaged students and non-disadvantaged students based on the data.

There were significant performance gaps between disadvantaged and non-disadvantaged students prior to taking SI courses as well as in SI courses (Table 1). Disadvantaged students had significantly lower academic performance prior to taking SI courses than their counterparts, for all four disadvantaged factors. The prior SI course performance gap was about 0.2 to 0.3 in terms of cumulative GPA in the beginning of term. The performance gap in SI courses became even larger, about 0.3 to 0.5 in terms of the average of course grades, which can be expected given that SI courses are usually high-risk courses.

[Table 1 is about here]

However, the performance gap decreased with the increase in SI visits. In other words, the more often disadvantaged students attended SI sessions, the smaller the performance gap became. Figure 1 plots the relationship between SI visits and student course performance by URM status, where the horizontal axis represents the number of SI sessions that students attended during a semester and the vertical axis represents the average course grade at each point of SI visits. The figure shows only the data for 0 to 24 SI visits since there few students had more than 24 visits. Two lines are the best-fitted trend lines based on a polynomial trend model of degree of 2. The solid line is for URM students and the dash line is for Non-URM students. The trend line model for course grade has R-Squared = 0.695 and P-value <0.0001. There are two vertical reference lines representing both numbers of SI visits of 8 and 16. Figure 1 clearly shows

that for all students, including URM and Non-URM students, the more frequent the SI session attendance, the better the course performance, even though the relationship was not linear. The most important finding is the dynamic change in course performance gap along the SI visits. The largest gap occurred for students who did not attend any SI session (SI visit =0), but the gap decreased with the increasing of SI visits. At eight SI visits, the performance gap was reduced by about 50%. When SI visits approached 16, the gap almost disappeared. The dynamic patterns of other three disadvantaged factors (FGS, Pell eligible and remedial status) are similar to that of URM status.

[Figure 1 is about here]

The performance gap between disadvantaged and non-disadvantaged students was close after 16 SI visits. Based on two cut-off points of 8 and 16 SI visits identified above, we further classified all students into four SI visit groups (0, 1-7 visits, 8-15 visits, and 16 or more visits) to see how the course performance gap changed within each SI visits group (Table 1).

The right panel of Table 1 shows the course performance gaps within each of four SI visit groups. There were no statistically significant differences between disadvantaged and non-disadvantaged students across all four disadvantaged factors in the SI visit group of 16 or more. In the other three SI visit groups (0, 1-7, and 8-15), disadvantaged students still had significantly lower average course grade than their counterparts across four disadvantaged factors.

Measuring the Degree of Disadvantage

So far, all our findings are bivariate, without considering interactions between the factors. To more accurately measure the degree of disadvantage of students and to avoid high inter-correlations among four disadvantaged factors when modeling the effects of SI visits, we combined the four factors and developed a composite scale called the disadvantage index. The

four disadvantaged factors in Table 1 are coded 1 or 0, with 1 indicating disadvantaged status (lower academic performance), so that the disadvantage index is the sum of the four disadvantage factors, with a range of 0 to 4 with 5 units at equal intervals of 1. The higher the values on the index, the higher the disadvantage; 0 means that students did not have any disadvantaged factors, and 4 means students have all four disadvantaged factors.

Table 2 displays the statistics by the disadvantage index. Only 10.6% of students had no disadvantaged factors, 17.0% had one, and 18.6% had two. The majority, 53.9%, had at least three factors. Table 2 also shows that the higher the disadvantage index, the lower the academic performance in both circumstances, prior to attending SI courses and within SI courses. Also, the bigger the performance gap becomes in comparison to students who did not have disadvantaged factors. For example, students with all four disadvantaged factors had a lower cumulative GPA at the beginning of term by 0.54 and lower SI course grade by 0.82.

[Table 2 is about here]

Modeling Course Grade

Table 3 shows the results of the tests of between-subjects effects from the GLM model with course grade as the dependent variable. The model accounts for of 25.4% of the total variance in course grade. The disadvantage index, SI visits, and their interaction are the statistically significant factors affecting the course grade. All eight controlling variables except course level were statistically significant. The most important factor (in terms of Partial Eta Squared) was the cumulative GPA in the beginning of term, followed by SI visits, course type, and course discipline.

[Table 3 is about here]

Based on the estimated parameters from the model, the disadvantage index had a significantly negative effect on course grade, while SI visits had a significantly positive effect on it. All other significant factors had expected effects on course grades. The following students had significantly higher course grades than their counterparts: those who had higher cumulative GPA in the beginning of term, were female, were in a higher class level, were full-time, were enrolled in non-STEM courses, and were enrolled in GE courses.

Evaluating the Effects of SI Visits on Course Performance Gap

There was a significant interaction effect of disadvantage index and SI visits on course grade. To clearly display how SI visits impacted the performance gap between disadvantaged and non-disadvantaged students, we plotted the means of predicted course grades by disadvantage index and SI visit groups as shown in Figure 2.

[Figure 2 is about here]

Figure 2 shows that an increase in SI visits reduce the performance gap in SI courses. The course grades converged; the gap disappeared for the SI visit group of 16+ because more disadvantaged students gained larger improvement with increased SI visits than less disadvantaged students, which is particularly true for students who have three or four disadvantaged factors. For example, when comparing students with 16+ visits to students with no SI visits, those who didn't have any disadvantaged factors improved by 0.63 (=3.21 in 16+ group – 2.58 in 0 group). On the other hand, students who had one, two, three, and four disadvantaged factors improved their average grade by 0.96 (=3.20-2.24), 0.83 (=2.91-2.08), 1.08 (=3.04-1.96), and 1.37 (=3.07-1.70), respectively. Students who had three or four factors and attended SI 16 or more times gained the largest improvement (more than one point). The performance gap thus narrowed and even closed for the SI visit group of 16+. For example, in the SI visit group of 0,

the performance gaps were: -0.34 (=2.24-2.58), 0.50 (=2.08-2.58), -0.62 (=1.96-2.58), and -0.88 (=1.70-2.58) for students who have one, two, three, and four factors, compared to students who didn't have any of the four factors. In the SI visit group of 16+, the corresponding gaps are -0.01 (=3.20-3.21), -0.29 (=2.91-3.21), -0.17 (=3.04-3.21), and -0.13 (=3.07-3.21).

In summary, after controlling for the influences of the cumulative GPA in the beginning of term and other student and course characteristics in the model, the more often students attended SI sessions, the higher their grades in high-risk courses were. Furthermore, the greater beneficiates were those entering with the greater disadvantage with more SI visits. Their performance gap narrowed with the increase of SI visits and finally closed when SI visits reached 16.

Discussion

Even though we found that the performance gap between disadvantaged and non-disadvantaged students narrowed and even closed at the point of 16 SI visits, we do not believe that there are substantial differences among SI visits of 15, 16 or 17. Instead, we believe that the finding above may relate to a certain regularity of SI attendance during a semester. In the university under this study, SI sessions are offered two to three times per week in a semester, usually over four months or 16 weeks. Thus, students in the SI visit group of 16 or more are more likely to have attended SI sessions regularly, perhaps at least once per week, though we do not have exact attendance data to verify this argument. To examine this argument, we surveyed the current SI Leaders on what they considered "regular," "less than regular," and "occasional" SI attendance. Of our 32 SI Leaders, 91.9 percent agreed or strongly agreed that a student who attends 16 or more SI sessions throughout the course of the semester is considered a "regular" attendee. When asked if a student who attends 8-15 SI sessions is considered a "less than

regular" attendee, 51.3 percent of SI Leaders agreed or strongly agreed. Lastly, when asked what defines an "occasional" SI attendee, 86.5 percent agreed or strongly agreed that attending 1-7 SI sessions would place a student within this attendance bracket.

When exploring the importance of regular student attendance to a support service such as SI, it is crucial to understand the needs of a disadvantaged student population and examine how SI as a program is structured to address these exact needs. Disadvantaged students encounter severe challenges due to two major factors: lack of necessary academic skills required for college success (Scott-Clayton, et al., 2014) and lack of engagement with the campus community which often leads to a decreased sense of belonging (Engle & Tinto, 2008). SI addresses these very needs as it utilizes peers to foster a collaborative learning environment which integrates content based study skills with social interactions. Through the strategies provided by the International Center of SI at UMKC such as, student-to-student interaction, think-pair-share and redirecting of questions, social interaction and college level study skills are promoted in all session. Urh and Jereb (2014) explored the idea of regularity through examining the ways in which new learning habits can be formed and reinforced. Their findings concluded that although new habits are indeed difficult to create, repetition is the key to developing strong behavioral patterns. Similar to this finding, through regular SI attendance and constant exposure to designed SI features, students have the opportunity to develop or reshape their learning habits.

This study added two new perspectives to the current research base when examining the effects of SI participation on students' learning outcomes: the total number of SI sessions attended and the disadvantage index. Most SI studies compared SI participants with nonparticipants based on a single cut-off point of SI sessions attended (such as 1, 3, 5, or even 12 sessions). There was no consistent operational definition of an SI participant and the decisions

for the cutoff point "were largely arbitrary and unsubstantiated" (Dawson, van der Meer, Skalicky, & Cowley, 2014, p. 619). Furthermore, assessing SI program based on the dichotomous participation status may overlook the more complicated effects of SI participation because students may participate in SI with various degree (a student may attend only one session to 24 sessions or even more). This study defined SI participation as SI visits, the total number of SI sessions a student attended during a semester, which accurately reflects the degree of SI participation a student had. By looking at the total number of SI sessions, this study demonstrated a full picture about how SI participation affect students' course performance and discovered the complicatedly positive but non-linear relationship between SI participation and course performance for all students in general and the differential effects of SI participation on course performance for different student groups.

SI was explicitly designed to target historically difficult courses but not to target at-risk students (Martin & Arendale, 1994). There were limited studies on the effects of SI for students from underrepresented population groups, such as first-generation and ethnic minority students (Dawson et al., 2014; Peterfreund, Rath, Xenos, & Bayliss, 2008; Rath, Peterfreund, Xenos, Bayliss, & Carnal, 2007). This study expanded the research base by looking at students based on their disadvantage index. Considering the possible overlapping among four disadvantage factors, this study combined the four disadvantage factors and developed the disadvantage index, which is a comprehensive and more accurate measure of the extent of disadvantage a student has. This not only made the estimation of the effects of SI participation more reliable, but also provided the new insights on how SI participation affect students differently, depending on their disadvantage index as shown in Figure 2.

From both new perspectives of the degree of SI participation (the total number of SI

sessions attended) and the extent of disadvantage status of students (the disadvantage index), this study discovered the differential effects of SI participation on students' learning outcomes, depending on both factors above, which further made a unique contribution to the current research. That is, the more disadvantaged students received larger performance improvement than less disadvantaged students with more SI visits. As a result, the performance gap in SI courses narrowed and finally closed for students who attended 16 or more visits. This study also tried to link the total number of SI sessions attended to the underlying regular pattern of SI participation during a semester and proposed that students in the SI visit group of 16 or more are more likely to have regularly attended SI sessions or participate in SI sessions on the weekly basis, which is supported by the responses from a follow-up survey of SI leaders. Thus, the findings from this study indicates how SI participation can help disadvantaged students to close their performance gap with non-disadvantaged students: attending SI sessions on the regular or weekly basis is critical.

Implications

With the new perspectives and the unique findings discussed above, this study provided the enriched implications for SI program, as well as other student supporting programs in general.

This study supported the findings in the literature that SI participation has positively impact students' performance in SI courses. Furthermore, this study indicated that it is critical to attend SI sessions on the weekly basis for disadvantaged students to close their performance gap with non-disadvantaged students. However, the further exploration on the data indicated that there is not much difference in SI participation among five disadvantaged groups of students. The lower panel of Table 2 displays SI participation by the disadvantage index. For all five

groups, the percentages of students who attended at least one SI session were from 35-37%, the average number of SI sessions attended ranges from 5.3 to 5.9 and the median SI sessions attendance is same as 3. All five index groups have similar distribution of attendance in the four SI visit groups. Furthermore, the majority (64%) of students, including disadvantaged students, did not participate in any SI sessions. Only 2.8% of students participated in 16 or more SI sessions, and another 5.5% participated in only 8-15 sessions. This pattern is also similar across all disadvantage levels. The finding above is consistent with the previous finding that the weakest students (whose cumulative GPA is below 2.0) received the largest benefits from SI but were less likely to participate in SI than other students (Yue, 2014). Clearly, more research is needed to understand why students, particularly disadvantaged students, are less likely to attend more SI sessions. And more SI improvement is needed to encourage more students, disadvantaged students in particular, to benefit from more regular SI attendance. Institutions might consider to mandatorily require disadvantaged students to participate in SI sessions on the weekly basis in helping them to succeed.

The implications of this study are also beyond SI program. There are various student supporting programs implemented on campuses. This study calls these programs to review their programs' impacts on students' learning outcomes from two new perspectives employed by this study. Dichotomous status of program participation may simplify the analysis but also lose many useful insights. Re-examining the program participation from the participation frequency (the number of times to participate) and regularity (the underlying regular pattern) beyond the dichotomous participation status, the differential effects of program participation for different student groups may exist. Thus, the program participation frequency and then the regularity or regular pattern may play an important role in reducing the performance gap for some special

student groups such as disadvantaged students like the case of SI program.

Institutions might develop their own disadvantage index similar to the one employed by this study to target the students who are in the most disadvantaged status and need the institutional supports the most. By combining all relevant factors and evaluating these factors simultaneously, the developed index would more accurately measure the needed status of students and allow these institutions to utilize their limited resources to support the students in the-most need. Given the importance of regular program participation for disadvantaged students to close the performance gap found in this study, institutions might consider to improve their programs or develop new interventions that allow or motivate these students to participate on the regular basis, even require them to participate in such intervention programs on the weekly basis in helping them to succeed at colleges.

In reviewing students' learning outcomes of high-impact practices in the literature to determine whether there was a differential outcome for participants in underserved student groups, Brownell and Swaner (2009) found that "there is little research that looks at learning outcomes for specific populations of students, and particularly underrepresented minority, low-income, and first-generation students" (p. 27-28). By combining two new perspectives of the program participation frequency/regularity and the disadvantage index to assess the programs, this study provided a new direction for researchers to identify the differential program effects on learning outcomes for specific student populations.

Limitations

This study is conducted at a large state university where the majority of students are in some degree of disadvantaged status. In addition, different institutions may offer SI sessions at the different frequency. The finding of the cut-off point of 16 SI visits may not apply to other

institutions. Thus, the study needs to be replicated in other institutions, such as research universities or community colleges.

This study is also limited by data available for analysis. Due to the fact that there were only a few upper division courses supported by SI sessions, the finding from this study cannot be generalized to upper division courses. Furthermore, this study didn't control for self-selection – SI participation is usually voluntary in nature. When modeling course grade and evaluating the effects of SI Visits on course performance, this study included the cumulative GPA in the beginning of term and other seven student and course characteristics as controlling variables in trying to reduce the self-selection bias. However, none of them can be assumed to be definitively a proxy for the self-selection or motivation. Thus, without accounting for this factor, an estimate of the effects of SI participation on course grade would be biased. Thus, our analysis may suffer from self-selection bias and needs to be addressed in future research by accounting for students' reasons for SI participation.

Finally, this study proposed that students in the SI visit group of 16 or more are more likely to have regularly attended SI sessions or participate in SI sessions on the weekly basis, which needs to be further verified based on the exact SI attendance data.

Conclusion

Based on the larger-scale dataset including 16,297 undergraduate students enrolled in 22 courses supported by SI sessions in a large state university in California, this study employed both techniques of data visualization and statistical modeling to answer the following questions: would SI visits affect students' course performance, and particularly, would SI visits help traditionally disadvantaged students to narrow the performance gap in SI courses? Course performance is measured by course grades and student disadvantaged status is defined by four

factors: URM status, FGS status, Pell Grant eligible status, and English/Math remedial status.

The study revealed that the number of SI visits was positively correlated with course performance. More importantly, the more disadvantaged students gained larger performance improvement than less disadvantaged students with increased SI participation. As a result, the performance gap in SI courses narrowed and finally closed for students who attended 16 or more visits. These findings remain statistically sound after controlling for cumulative GPA in the beginning of term and other student and course characteristics. The study not only confirmed the previous finding in literature that SI participation has positive impact on students' learning outcomes, but also further identified the differential effects of SI participation on disadvantaged students, depending on both factors of the degree of SI participation and the extent of students' disadvantage status. This study provided valuable implications for SI program to help disadvantaged students to succeed. All students including both disadvantaged and non-disadvantaged students would benefit more from more SI participation. Furthermore, more SI participation is more important for disadvantaged students. That is, to close the performance gap, disadvantaged students should attend SI sessions regularly or on the weekly basis.

The implications of this study are beyond SI program. The large achievement gap in bachelor degree attainment in higher education between traditionally disadvantaged and non-disadvantaged students has been receiving more and more attention with the increasing diversity of student population in higher education in the United States of America. Given that the process of graduating towards a degree is not continuous but partitioned in academic terms (Bahr, 2009), the achievement gap is the cumulative result from the course performance gaps over terms. Thus, seeking an effective intervention to help disadvantaged students to close the gaps in courses is a challenging task facing higher education institutions. This study provided enriched implications

for institutions to effectively fulfil such a task. There are various student supporting programs implemented on campuses. Institutions might review these programs by identifying the differential effects of these programs on students' learning outcomes from the new perspectives of the participation frequency and regularity (or the underlying regular patterns) for disadvantaged students. Moreover, institutions might develop the disadvantage index to more accurately measure students' degree of disadvantage and then target the most disadvantaged students who also need the institutional supports the most. In this way, the institutions can efficiently allocate their limited resources to help these students to close the performance gap and finally the achievement gap. This study indicated the importance of regular intervention or program participation for disadvantaged students. Thus, the institutions might improve their supporting programs to allow or encourage these students to participate in the programs more frequently or on the regular basis.

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Table 1

Performance Gap Between Disadvantaged and Non-disadvantaged Students

	All students			SI Visit Group							
	Enrolled Headcount	Prior to SI courses	In SI courses	Enrolled Headcount				Avg. SI Course grade			
		Avg. Cumulative GPA in the beginning of term	Avg. Course grade	0	1-7	8-15	16+	0	1-7	8-15	16+
Grand Total	16,297	2.94	2.14	10,438	4,500	903	456	1.98	2.31	2.66	2.93
URM status											
Non-URM	5,505	3.12	2.36	3,547	1,540	289	129	2.22	2.55	2.81	3.00
URM	10,792	2.85	2.02	6,891	2,960	614	327	1.85	2.19	2.59	2.91
Gap (URM - Non-URM)		***-0.26******	***-0.34******					***-0.37******	***-0.36******	***-0.22****	***-0.09***
FGS status											
Non-FGS	5,414	3.08	2.33	3,405	1,572	298	139	2.17	2.52	2.87	2.96
FGS	10,883	2.87	2.04	7,033	2,928	605	317	1.88	2.21	2.55	2.92
Gap (FGS - Non-FGS)		***-0.20******	***-0.29******					***-0.29******	***-0.31******	***-0.32******	***-0.03***
Pell eligibility status											
Not eligible	6,423	3.08	2.33	4,060	1,874	329	160	2.18	2.51	2.80	3.00
Eligible	9,874	2.85	2.01	6,378	2,626	574	296	1.85	2.17	2.58	2.90
Gap (Eligible - Not eligible)		***-0.23******	***-0.32******					***-0.33******	***-0.34******	***-0.22****	***-0.10***
Eng/Math remedial status											
Non-Remedial	7,896	3.10	2.37	5,089	2,182	407	218	2.24	2.56	2.74	2.99
Remedial	8,401	2.79	1.91	5,349	2,318	496	238	1.73	2.08	2.59	2.88
Gap (Remedial - Non-Remedial)		***-0.31******	***-0.46******					***-0.51******	***-0.47******	***-0.15****	***-0.11***

** P < 0.05; ** P < 0.01; *** P < 0.001* One-way ANOVA for cumulative GPA and course grade.

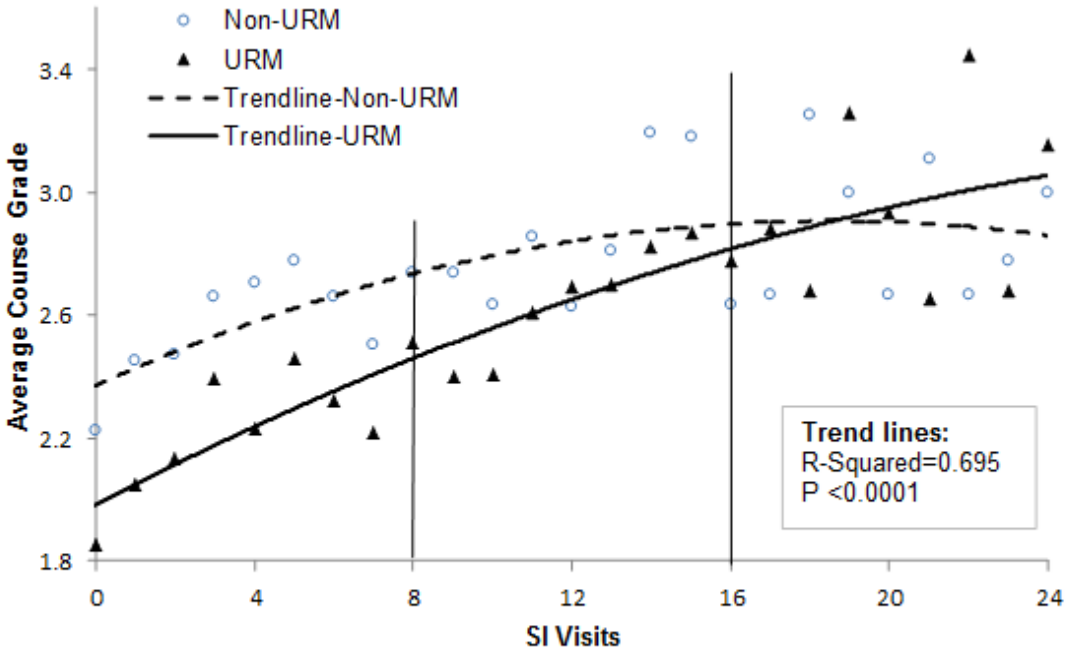


Figure 1. Number of SI Visits and Course Performance

Table 2

Enrollment, Performance and SI Participation by Disadvantage Index

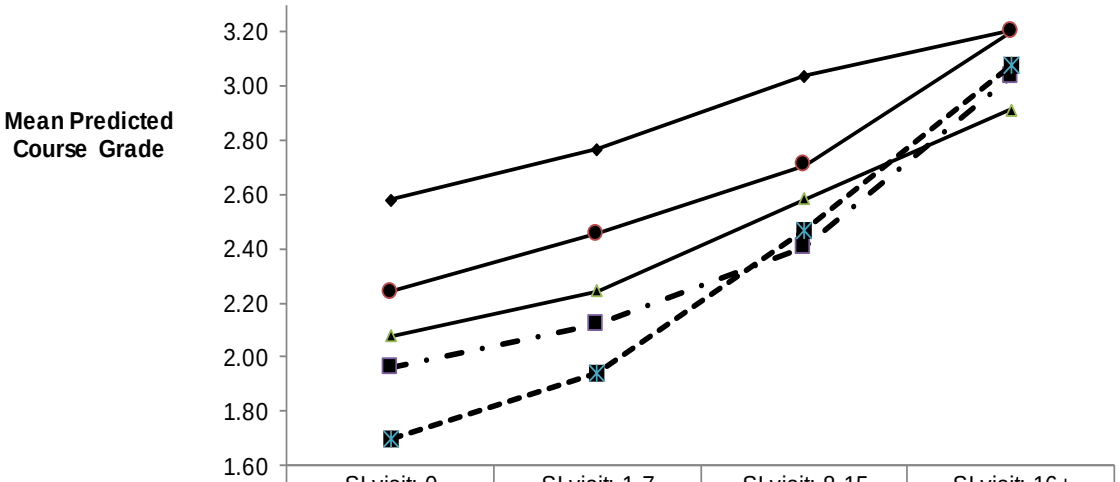
		Disadvantage index					Grand Total
		0	1	2	3	4	
Enrollment							
Enrolled Headcount		1,724	2,763	3,031	3,991	4,788	16,297
Enrolled %		10.6%	17.0%	18.6%	24.5%	29.4%	100.0%
Course performance							
Avg. Cumulative GPA in the beginning of term		3.27	3.11	3.01	2.89	2.73	2.94
Avg. Course grade		2.68	2.35	2.18	2.06	1.86	2.14
Performance Gap (compared to students whose disadvantage index = 0)							
Avg. Cumulative GPA in the beginning of term		0.00	-0.16	-0.26	-0.37	-0.54	
Avg. Course grade		0.00	-0.33	-0.50	-0.62	-0.82	
SI Participation							
Enrolled Headcount	0	1,073	1,790	1,912	2,615	3,048	10,438
	1-7	521	759	871	1,065	1,284	4,500
	8-15	84	154	157	211	297	903
	16+	46	60	91	100	159	456
	Total	1,724	2,763	3,031	3,991	4,788	16,297
% of Column	0	62.2%	64.8%	63.1%	65.5%	63.7%	64.0%
	1-7	30.2%	27.5%	28.7%	26.7%	26.8%	27.6%
	8-15	4.9%	5.6%	5.2%	5.3%	6.2%	5.5%
	16+	2.7%	2.2%	3.0%	2.5%	3.3%	2.8%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
SI visits (Participated students only)	Enrolled Headcount	651	973	1,119	1,376	1,740	5,859
	Mean	5.3	5.3	5.3	5.4	5.9	5.5
	Median	3.0	3.0	3.0	3.0	3.0	3.0
	SE	6.8	6.2	6.1	6.5	6.7	6.5

Table 3

Modeling Course Grade: Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7638.416a	26	293.785	208.764	0.000	0.254
Intercept	138.305	1	138.305	98.280	0.000	0.006
Disadvantage index	203.605	4	50.901	36.170	0.000	0.009
SI Visits	362.164	1	362.164	257.354	0.000	0.016
Disadvantage index * SI Visits	19.366	4	4.841	3.440	0.008	0.001
Gender	13.783	1	13.783	9.795	0.002	0.001
Student level	113.832	3	37.944	26.963	0.000	0.005
Major of college	283.181	8	35.398	25.154	0.000	0.012
Full-Time status	20.417	1	20.417	14.508	0.000	0.001
Course disciplines	309.253	1	309.253	219.756	0.000	0.014
Course level	1.086	1	1.086	.772	0.380	0.000
Course type	329.029	1	329.029	233.808	0.000	0.014
Cumulative GPA in the beginning of term	4738.619	1	4738.619	3367.272	0.000	0.174
Error	22480.940	15975	1.407			
Total	103076.000	16002				
Corrected Total	30119.356	16001				

a. R Squared = .254 (Adjusted R Squared = .252)



Disadvantage Index	SI visit: 0	SI visit: 1-7	SI visit: 8-15	SI visit: 16+
0	2.58	2.77	3.04	3.21
1	2.24	2.46	2.71	3.20
2	2.08	2.25	2.58	2.91
3	1.96	2.12	2.41	3.04
4	1.70	1.94	2.47	3.07

Figure 2. Mean Predicted Course Grade by Disadvantage Index and SI Visit Group