SUPPLEMENTAL INSTRUCTION EFFECTIVENESS REPORT

SPRING 2015

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ABSTRACT

Supplemental Instruction (SI) is a widely implemented learning support program aimed at increasing student success in traditionally difficult courses (Dawson, Skalicky, Cowley, 2014). Research examining course outcomes do not always reach similar conclusions regarding the institutional utility of SI (Oja, 2012). At Citrus College, SI has been an integral activity in supporting students in STEM courses. As a result, the efficacy and institutional feasibility of SI services must be evaluated. This current study investigates the effectiveness of SI among seven different math and science courses while controlling for demographic and academic aptitude variables. Students (N = 1,820) were separated into three groups based on their SI attendance, including a Low-Dose (LD) SI group (n = 384), a High-Dose (HD) SI group (n = 318) and non-participant (NP) group (n = 1, 118). Participants in the LD group consisted of students who attended SI between 1-4 times, while participants in the HD group consisted of students who attended SI five or more times. Success outcomes were compared across courses and between groups.

For all courses, HD participants showcased higher success rates than their LD and NP counterparts. In several courses, the differences between group success rates were greater between HD participants and LD participants than between LD and non-participants. Statistical analysis revealed that individuals with higher preexisting GPA's are more likely to succeed, regardless of their level of participation. Only in MATH032 did HD exposure maintain a significant effect on course success in the presence of GPA. These findings suggest that the greatest predictive variable of an individual student's success in a math and science course is their preexisting GPA; however, SI may be efficacious in lower-level courses if exposure is high.

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BACKGROUND AND SIGNIFICANCE

Today, higher education encounters a plethora of students with diverse backgrounds and varying educational needs. Colleges attempt to be equitable in their efforts to assist students in their collegiate experience. Nevertheless, there maintains a concern regarding the successfulness of students' academic pursuits per low pass and retention rates in many majors, especially areas of study with traditionally difficult subject matter (Rath, Peterfreund, Bayliss, Runquist, & Simonis, 2011). These academic concerns have multifaceted etiologies stemming from a flux of interactions including economic, racial, and cultural (Meling, Mundy, Kupczynski, & Green, 2013). Post-secondary institutions often seek government grants to address scholastic factors associated with student learning outcomes by implementing programs designed around best practices. Citrus College has previously been granted funding to assist and increase students in science, technology, engineering and mathematics (STEM) courses. The Race to STEM program aims to achieve six program objectives including:

Objective 2

> Increase the percentage of STEM Academy students and college-wide STEM students who successfully transition from Bridge-to-STEM to STEM by successfully completing both college-level Math and enrollment in at least one core science course.

Objective 3

> Increase the percentage of students, especially Hispanics, who complete the Citrus STEM Academy Program as measured by completion of at least one transfer-level Math course, at least one transferable core science course, and completion of a STEM Academy approved project.

One of the primary strategies in achieving these objectives is through Supplemental Instruction. Supplemental Instruction (SI) initiated from the University of Missouri-Kansas City (UMKC) in 1973 and is presently a global educational intervention designed to support students in high-risk courses (Dawson, Skalicky, Cowley, 2014). Many universities and community colleges delineate STEM courses as high-risk; thus, the provision of SI in STEM is not unconventional. This widespread use of SI can be partly attributed to the claims made by the United States Department of Education in 1992, which acknowledged SI as an effective educational tool for increasing mean final course grades (Dawson et al, 2014).

SI is distinguishable from traditional tutoring; in fact, one of SI's characteristics is its interactive approach to learning- a stark difference from one-on-one tutoring sessions. SI is more accurately described as regularly scheduled, informal out-of-class review sessions lead by the Supplemental Instruction Leader, a student who has successfully taken the course. Supplemental Instruction Leaders plan and conduct study sessions two times a week, directly before or after the class. These peer-focused group sessions implemented at strategic intervals describe the SI model (Dawson et al, 2014).

Despite its impressive distribution across institutions, when evaluated, SI often does not showcase consistent effects (Dawson et al, 2014). In fact, much of the literature is not congruent regarding the impact SI has on student course success (Dawson et al, 2014). For instance, positive associations between SI and student course grades can be identified when key variables (such as GPA and credits earned) are left out of primary analysis. However, when these variables are included in analyses, such tends to drive the association, designating minimal variance in student course grades explained by SI (Dawson et al, 2014). Moreover, many studies misappropriate the employ of statistical analysis to evaluate the effects of SI on student final grades. Specifically, a methods-focused study conducted by Bowles and Jones (2003) highlighted the issues with using standard statistical techniques (like Ordinary Least Squares regression) when evaluating outcomes that are intrinsically categorical in nature and maintain restricted ranges. Furthermore, problems regarding self-selection and inappropriate operationalization of dependent variables can pose threats to the validity of results (Bowles & Jones, 2003).

The purpose of this study is to determine the efficacy of SI on student final course grades for the spring 2015 semester. This study aims to test the hypothesis that SI positively effects course success by comparing SI users against non-users and assessing the frequency of sessions attended on course final grade. The current non-experimental evaluation breaks away from previously used analytic techniques and turns to more robust statistical methodology to reach conclusions. Therefore, this study upholds two purposes: 1) the primary aim of juxtaposing the subsequent results with the abovementioned objectives, and 2) providing a more methodologically suitable evaluation contributing to a larger body of knowledge that could serve as an indicator of the utility of SI within the framework of general education (GE) STEM courses.

METHODS

Participant Characteristics

Inclusion/Exclusion

Participants in this study represent students who were enrolled in the spring 2015 semester in 46 sections of seven math and core science courses supported by SI (***N*** = 1,820). These courses consist of BIOL105, CHEM103, MATH030, MATH032, MATH142, MATH150 and MATH151. SI is openly available to any student who is enrolled in a section of a course that is supported for that semester. Table 1 shows the overall enrollment for each course supported by SI in the spring 2015 semester.

TABLE 1. Course Enrollment

Course	Enrollment	Sections Supported by SI
BIOL105	797	17
CHEM103	42	2
MATH030	310	8
MATH032	127	4
MATH142	101	4
MATH150	405	10
MATH151	38	1
Total	1820	46

Demographic Characteristics

The age range of the sample was 17 to 59, with a mean age of 22.6 years (SD = 5.2). The gender breakdown was 750 males (41%), 1,036 (57%) females, and 34 students who did not disclose gender (2%). The majority of students were Hispanic (66%), while 17% were White, and 9% were Asian. Students who were Black, Native American, Pacific Islander, two or more races, or declined to state made up 8% of the sample when combined together. Figures 1 and 2 show the gender and ethnicity distributions. Citrus College is characterized as a Hispanic Serving Institution (HSI); this facet of the college is made apparent when examining the ethnic distribution for the spring 2015 semester (see figure 2 and table 2).

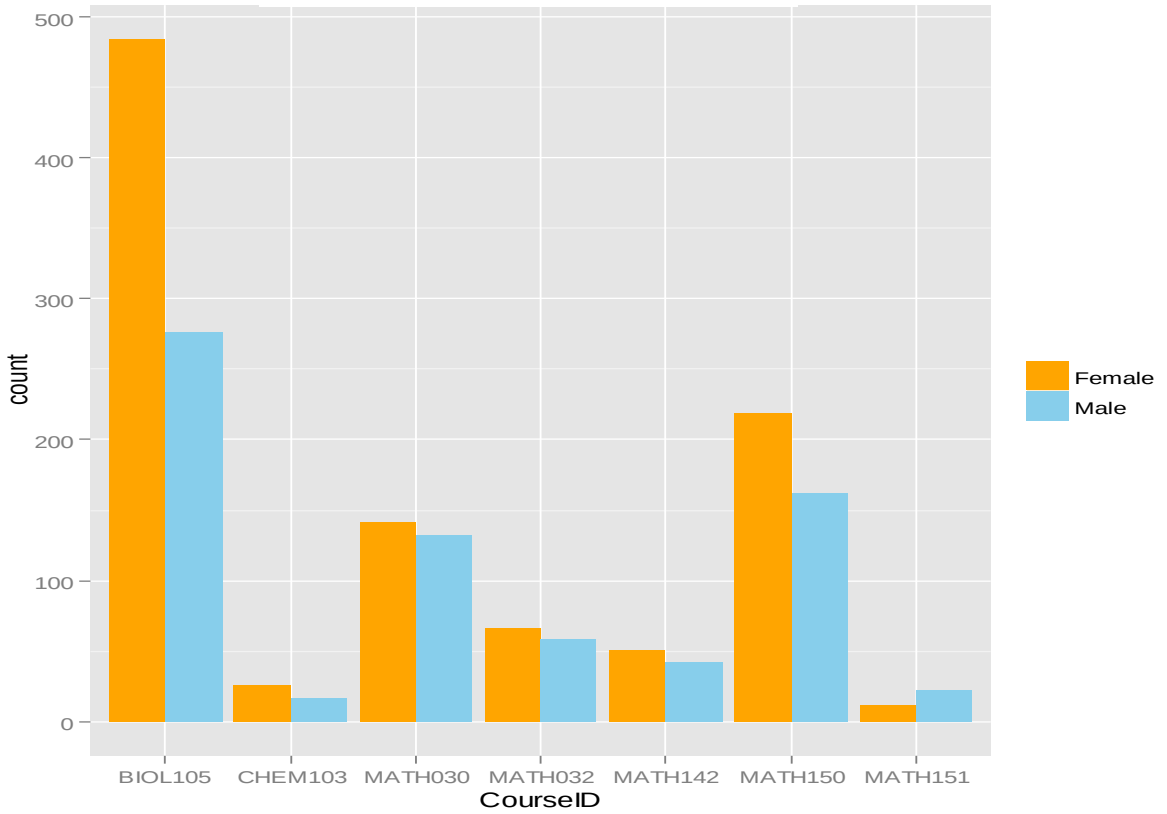

FIGURE 1. Gender distribution by course. Females are more prevalent in every course except MATH151.

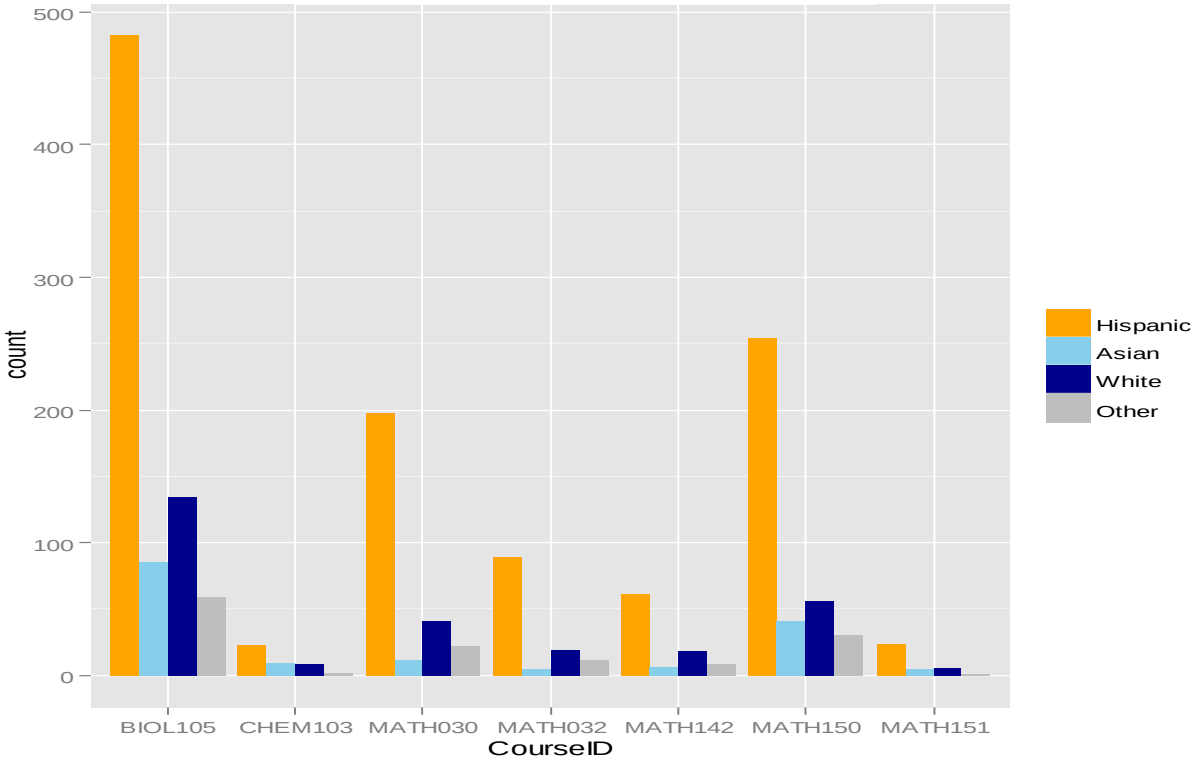

FIGURE 2. Ethnicity distribution by course. Hispanics are most prevalent in every course.

TABLE 2. Group proportions by ethnicity and course

	Hispanic			Asian			White			Other			Total			
	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	Total
BIOL105	39%	14%	10%	8%	2%	2%	11%	4%	3%	5%	2%	1%	62%	22%	16%	100%
CHEM103	26%	24%	5%	10%	7%	5%	14%	2%	2%	2%	0%	2%	52%	33%	14%	100%
MATH030	50%	11%	10%	2%	1%	1%	9%	3%	3%	6%	1%	2%	68%	17%	15%	100%
MATH032	38%	19%	15%	2%	1%	0%	11%	2%	2%	6%	3%	2%	57%	25%	18%	100%
MATH142	25%	19%	23%	2%	3%	1%	6%	4%	8%	5%	2%	3%	38%	28%	35%	100%
MATH150	41%	13%	12%	9%	1%	1%	8%	3%	3%	5%	2%	1%	63%	20%	17%	100%
MATH151	45%	5%	24%	8%	0%	3%	8%	3%	3%	0%	0%	3%	61%	8%	32%	100%

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant
**Percentaged across by course
Note. Percentages are rounded to the nearest whole percent

Table 3 shows reveals that females make up a greater proportion for both low and high dose SI groups in every course except for MATH151 (LDP = 5% to 3%; HDP = 29% to 3%).

TABLE 3. Group proportions by gender and course

	Male			Female			Total			
	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	Total
BIOL105	24%	8%	5%	39%	15%	10%	62%	22%	15%	100%
CHEM103	26%	10%	2%	26%	24%	12%	52%	33%	14%	100%
MATH030	37%	6%	6%	31%	11%	9%	68%	17%	15%	100%
MATH032	27%	11%	8%	30%	15%	9%	57%	26%	17%	100%
MATH142	20%	12%	15%	17%	16%	19%	37%	28%	34%	100%
MATH150	28%	9%	6%	36%	11%	11%	63%	20%	17%	100%
MATH151	32%	5%	29%	29%	3%	3%	61%	8%	32%	100%

*Students with gender Not-Disclosed excluded
**Percentaged across by course

Measures

Data Collection

This study utilized the Citrus College local database Banner to identify students enrolled in math and core science courses for the spring 2015 semester. This information was used in the STEM Center as a roster for tracking students attending SI sessions. After the semester, the data was further linked to local database files to sync attendance with student's final grade for the course.

Variables

Gender. To control for possible differences between males and females, a gender variable was dummy coded with females as the reference group. All statistical analysis involving gender excluded students who did not disclose their gender.

Ethnicity. An ethnicity variable was dummy coded designating Hispanics as the reference group. Due to an extremely low frequency among students who were Black, Native American, Pacific Islander, two or more races, and those who declined to state, these ethnicities were compiled to make a "Other" category.

SI Sessions Attended. SI sessions attended were determined per the roster utilized in the STEM center. Each session attended contributed to one count. All participants without a minimum of one SI session attendance were excluded from analysis. Standard deviation trimming method was used to exclude extreme scores on SI.

GPA. Collegiate GPA has been identified as the best proxy for student academic aptitude (Grove, Wasserman, & Grodner, 2006) and represents a student's preexisting, overall GPA. Data were acquired using the Citrus College local database Banner and obtained prior to the end of the spring 2015 semester; thus, the data for GPA do not include that which was completed in the spring 2015 semester.

Final Grade. Final grade represents a student's ending semester mark for a course. Final grade consists of the following: A, B, C, D, and F/ FW (failed/withdraw)/W (withdraw). Final grade was used as the outcome variable when relevant.

Success. Success was the primary outcome variable of this study. Students were dummy coded as either having a successful (1) or unsuccessful (0) course outcome. Success was operationalized as students who received a course final grade of either A, B, or C. Unsuccessful students were categorized as those who received a course final grade of D, F, FW, or W.

SI Participants/Non-Participants In an effort to identify more discrete differences between SI participants and non-participants, students were separated into three different groups: Non-participants (n = 1,118), Low-Dose participants (n = 384), and High-Dose participants (n = 318).

LD participants (LDP) were defined as students who had attended an SI session 1 - 4 times throughout the semester and HD participants (HDP) were defined as students who had attended an SI session $\geq$ 5 times. This distinction inhibits the over-inflation of the non-participant pool with individuals exposed to SI. However, in courses where samples and group sizes were low, LD and HD participants were combined for a composite SI group (n = 318).

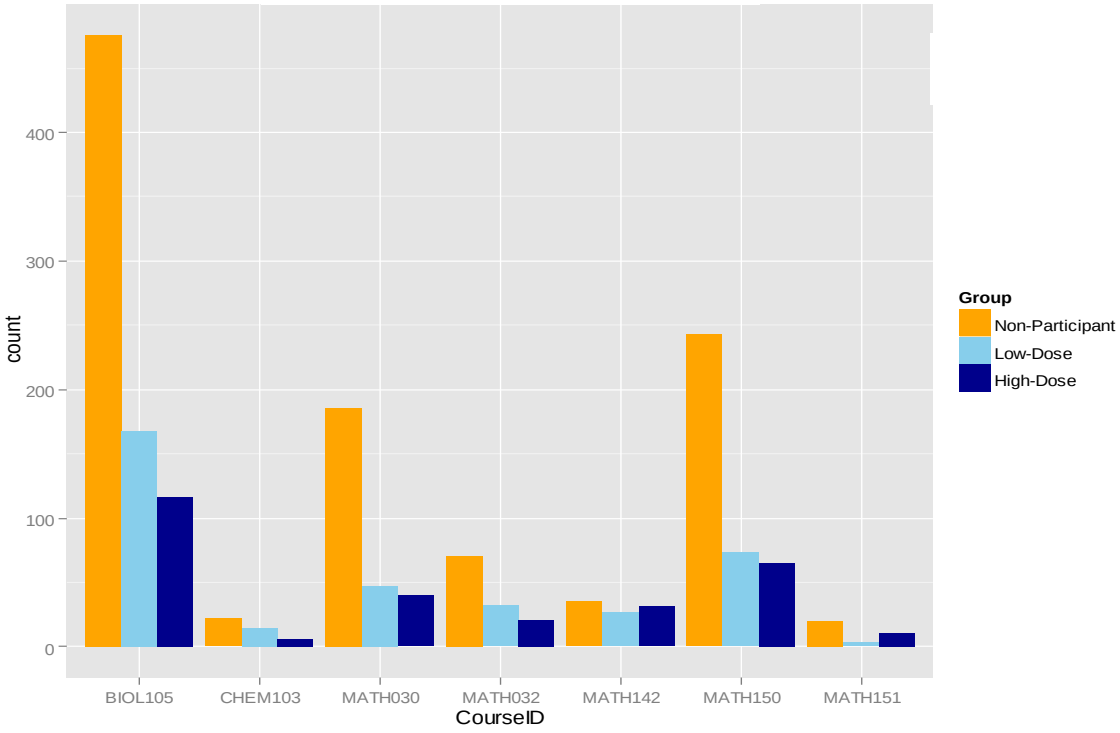

FIGURE 3. SI group distribution by course. Exceedingly more Non-participants than LD and HD participants are observed for most courses except when the overall course size is exceptionally low, such as CHEM03 and MATH151.

Analytic Strategy

All analyses were performed and graphs constructed using statistical package R version 3.1.3. Several analyses were conducted to evaluate the effects of SI on course outcomes. Considering the dynamics of each course separately, different statistical techniques were used to accommodate the varying SI group distributions and course size. Descriptive statistics were used to display relevant data on gender and ethnicity distributions, average GPA scores, as well as rates for success. Every course was inferentially tested; if a statistically significant relationship between SI participation and course success was identified in Part I testing, a more rigorous, inclusive analysis was conducted. Inferential tests were evaluated at 0.05 α level.

BIOL105. In BIOL105, two different analyses were performed. For Part I, a three-way loglinear analysis examined the relationship between gender, SI participation, and course success. In Part II, a multinomial logistic regression analysis was used to model the predictive nature of GPA, ethnicity, and SI sessions on final course grade. In addition, this model examined the interaction between GPA and number of SI sessions attended on final course grade. Below is the model equation:

$$P(\text{Final Grade}) = \frac{1}{1+e^{-(b0+b1GPA+b2Asian+b3White+b4Other+b5SI+b6GPA*SI+e)}}$$

CHEM103. In CHEM103, a chi-square test was used to examine if success was more likely for participants or non-participants of SI. In this analysis, LD and HD participants were combined to form one SI group due to the low sample size.

MATH030. In MATH030, a hierarchical binomial logistic regression analysis was conducted examining the predictability of GPA and SI participation on course success. Below is the model equation:

$$P(\text{Success}) = \frac{1}{1+e^{-(b0+b1GPA+b2LDP+b3HDP+e)}}$$

MATH032. In MATH032, two different analyses were performed. For Part I a chi-square test was used to examine if success was more likely for participants or non-participants of SI. In this analysis, LD and HD participants were combined to form one SI group. In Part II, a hierarchical binomial logistic regression analysis was conducted examining the predictability of GPA and SI participation (examining LD and HD) on course success. Below is the model equation:

$$P(\text{Success}) = \frac{1}{1+e^{-(b0+b1Male+b2Asian+b3White+b4Other+b5GPA+b6LDP+b7HDP+e)}}$$

MATH142. In MATH142, a hierarchical binomial logistic regression analysis was conducted examining the predictability of GPA and SI participation on course success. Below is the model equation:

$$P(Success) = \frac{1}{1+e^{-(b0+b1GPA+b2LDP+b3HDP+e)}}$$

MATH150. In MATH150, a hierarchical binomial logistic regression analysis was conducted examining the predictability of GPA and SI participation on course success. Below is the model equation:

$$P(Success) = \frac{1}{1+e^{-(b0+b1GPA+b2LDP+b3HDP+e)}}$$

MATH151. In MATH151, a chi-square test was used to examine if success was more likely for participants or non-participants of SI. In this analysis, LD and HD participants were combined to form one SI group.

BIOL105 RESULTS

Part I

Descriptive Statistics

In BIOL105, there were a total of 797 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 496 females (62%), 285 males (36%), and 16 students who did not disclose their gender (2%). Non-participants made up 62% of the course total, LD participants made up 22% of the total, and HD participants, who were the smallest group, consisted of 16% of the total number of students enrolled in BIOL105.

Success. Success rates were calculated for each SI group. Non-participants had the lowest success rate (68%), while HD participants showcased the highest success rate (87%); thus, SI dosage delineates a trajectory of success per participants with greater exposure to SI performing better than participants with less exposure. It is interesting to note that there is a greater success discrepancy between HD participants and LD participants (-14%) than there is between LD participants and Non-participants (-5%).

TABLE 4. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	335	160	495	68%
LDP	128	47	175	73%
HDP	111	16	127	87%
Total	574	223	797	72%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

Inferential Test

A three-way loglinear analysis produced a final model that did not retain all effects, indicating there was no significant three-way interaction between gender, SI group, and course success; the likelihood ratio of the final model was χ^2 (8) = 175.90, p = 0. There was however, a significant two-way interaction between SI group and course success, χ^2 (2) = 19.99, p < .001. To break down this effect, separate chi-square tests on SI group and Success variables were performed for males and females. For males, there was a significant association between SI group membership and success, χ^2 (2) = 10.19, p < .001; this association was also identified in females χ^2 (2) = 8.76, p = .01. Examination of standardized residuals revealed that among males, significantly less HD participants were unsuccessful than expected (z = -2.29); the same phenomena was observed in females (z = -2.19). To further explain, the association between SI group and success is mainly driven by HD participants performing significantly not as poorly as Non-participants and LD participants, regardless of gender.

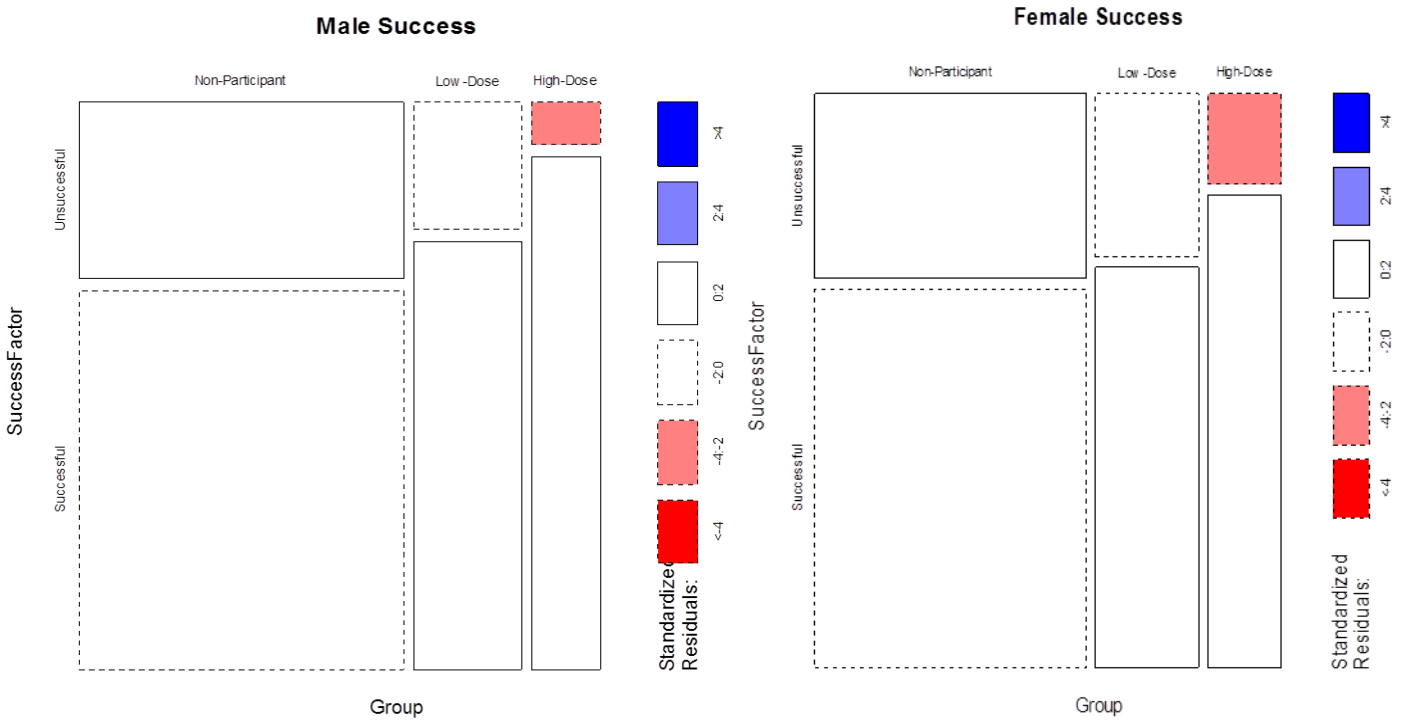

FIGURE 4. - Mosaic plots displaying the size of cell frequencies for male and female success by SI group. The highlighted segments reveal significant standardized residuals, indicating the primary component driving the association between SI group and success variables.

BIOL105 RESULTS

Part II

Descriptive Statistics

In BIOL105, there were a total of 292 students who attended at least one SI session during the 2015 spring semester. Among this group, 186 were Hispanic, 28 were Asian, 53 were White, and 25 were other races. Figure 6 shows the mean scores for SI and GPA by ethnic category.

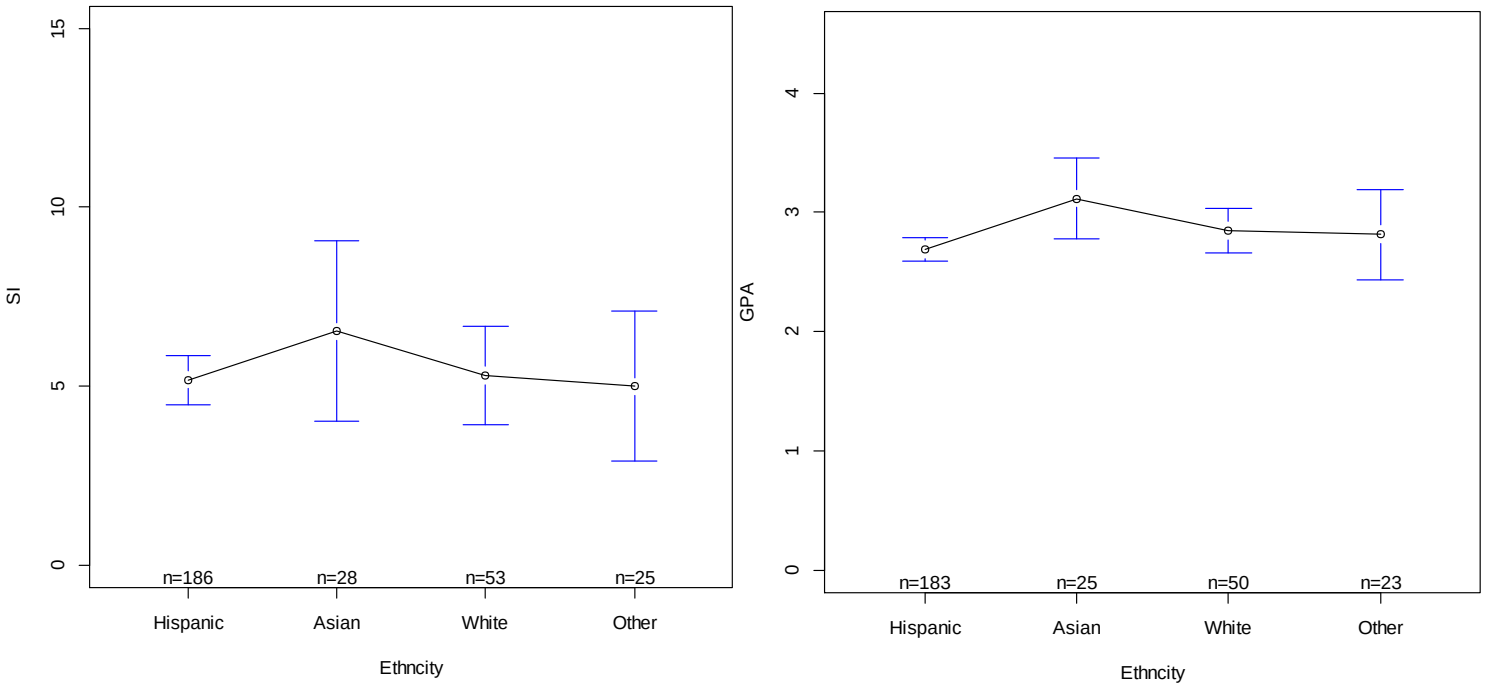

FIGURE 5. - Mean plots for SI Sessions and GPA by ethnicity group.

Final Grade. The distribution of final grade was examined for each ethnicity group. Proportionally, Hispanics had the highest rates of F's and W's (13%); Whites had the second highest rates with 11% of all Whites earning a final grade of F or W. Other ethnic group (composite group made up of Blacks, two or more races, Pacific Islanders, Native Americans, and those who declined to state) had the highest rates of D's (16%). In comparison, Whites had the highest rates of C's (32%) and B's (43%). The proportion of Asians that earned a final grade of A was higher than the proportion of any other ethnic group; 25% of all Asians earned an A in

BIOL105. Interestingly, the Other ethnic group earned an equal proportion of B's as they did C's (28%). Asians and Whites both had final grade B as the largest proportion of final grade earned, respectively.

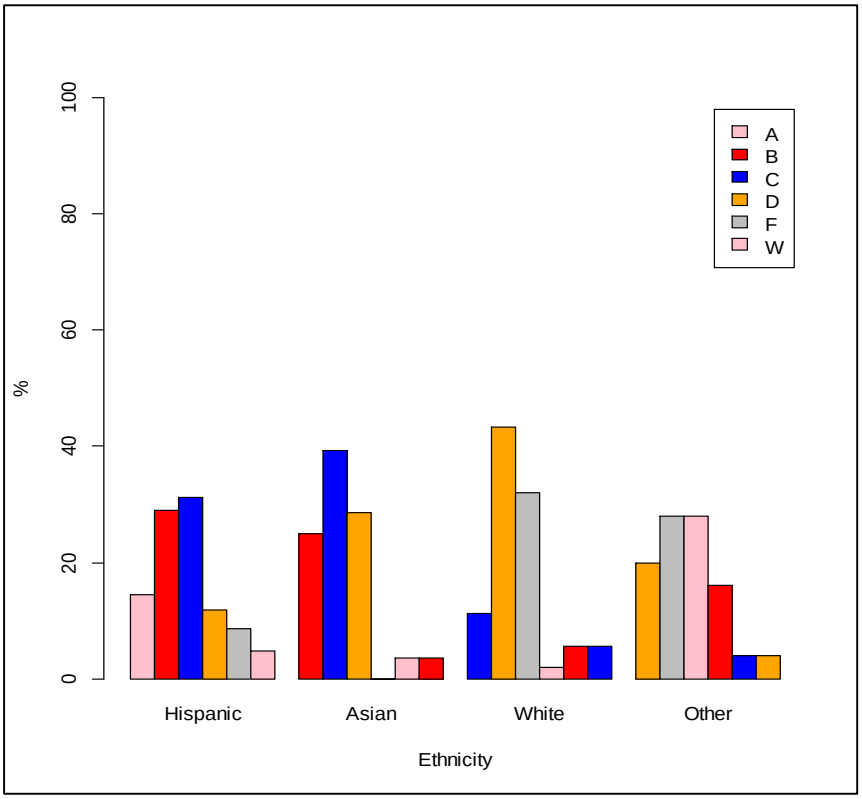

FIGURE 6. – Proportion of each ethnic groups earning a semester final grade of A, B, C, D, or F (or W)

Inferential Test

A multinomial logistic regression analysis was conducted to determine the ability of SI sessions to predict semester final grade. Students prior GPA was included in the model to control for students aptitude and motivation. Whether GPA was high significantly predicted whether students earned a final grade of A or F (or W), $b = 4.08$, $p < .001$. The odds ratio reveals that as students GPA increased by a unit, the change in the odds of earning final grade A (rather than earning an F or W) is 59.09: students are more likely to earn an A than an F or W if they have a high GPA. Whether GPA was high significantly predicted whether students earned a final grade of B or an F (or W), $b = 2.61$, $p < .001$. The odds ratio reveals that as students GPA increased by a unit, the change in the odds of earning a final grade B (rather than earning an F or W) is 13.59: students are more likely to earn a final grade of B than an F or W if they have a high GPA. Whether GPA was high significantly predicted whether students earned a final grade of C or an F (or W), $b = 1.41$, $p < .001$. The odds ratio reveals that as students GPA increased by a unit, the change in the odds of earning final grade C (rather than earning an F or W) is 4.08: students are

more likely to earn a final grade of C than an F or W if they have a high GPA. In contrast, ethnic groups do not have a predictive role in determining final grade.

SI was not significant for any pair comparison of outcome categories (A vs. F or W, B vs F or W, C vs. F or W). SI did not significantly predict whether students earned an A rather than an F or W, $b = 0.31$, $p = .396$. SI did not significantly predict whether students earned a B rather than an F or W, $b = 0.35$, $p = .237$. SI did not significantly predict whether students earned a C rather than an F or W, $b = 0.24$, $p = .404$. Finally, SI did not significantly predict whether students earned a D rather than an F or W, $b = 0.22$, $p = .509$. This model also included an interaction term between GPA and SI that did not yield significant results in any comparison. Table 4.3 on page 15 shows the results for the final model.

TABLE 4.1- Results of multinomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Earning Final Grade A vs. Earning Final Grade F or W				
Intercept	-12.36 (2.48)***			
GPA	4.08 (0.84)***	11.36	59.09	307.51
Asian	-0.04 (1.07)	0.12	0.96	7.83
White	-0.98 (0.80)	0.08	0.37	1.80
Other Race	0.16 (1.07)	0.14	1.17	9.65
SI	0.31 (0.37)	0.66	1.37	2.81
GPA × SI	-0.03 (0.14)	0.74	0.97	1.28
Earning Final Grade B vs. Earning Final Grade F or W				
Intercept	-6.97 (1.65)***			
GPA	2.61 (0.63)***	3.92	13.59	47.16
Asian	0.53 (0.95)	0.26	1.70	11.02
White	0.39 (0.58)	0.48	1.48	4.58
Other Race	0.42 (0.94)	0.24	1.52	9.65
SI	0.35 (0.30)	0.79	1.42	2.54
GPA × SI	-0.05 (0.12)	0.75	0.95	1.21
Earning Final Grade C vs. Earning Final Grade F or W				
Intercept	-3.31 (1.42)*			
GPA	1.41 (0.57)*	1.33	4.08	12.51
Asian	0.62 (0.89)	0.33	1.86	10.61
White	0.01 (0.56)	0.34	1.01	3.05
Other Race	0.49 (0.91)	0.28	1.62	9.58
SI	0.24 (0.29)	0.73	1.27	2.22
GPA × SI	-0.02 (0.12)	0.77	0.98	1.23
Earning Final Grade D vs. Earning Final Grade F or W				
Intercept	-0.34 (1.42)			
GPA	-0.08 (0.62)	0.27	0.92	3.09
Asian	-16.24 (2211.47)	0.00	0.00	—
White	-1.71 (1.13)	0.02	0.18	1.67
Other Race	0.54 (0.97)	0.25	1.72	11.59
SI	0.22 (0.33)	0.65	1.24	2.35
GPA × SI	-0.04 (0.14)	0.72	0.96	1.26

Note. R^2 = .17 (McFadden), Model χ^2 (20) = 140.36, $p < .001$, *$p < .05$. **$p < .01$ ***$p < .001$

CHEM103 RESULTS

Descriptive Statistics

In CHEM103, there were a total of 42 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 26 females (62%) and16 males (38%). Twenty-two students were non-participants, while 20 students were SI participants (students who attended at least 1 SI session).

Success. Success rates were calculated for each SI group. Non-participants had a lower success rate (77%) then SI participants (95%).

TABLE 5. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	17	5	22	77%
SIP	19	1	20	95%
Total	36	6	42	86%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, SIP=SI participant

Inferential Test

A chi-square test was conducted to evaluate the association between SI participants and non-participants on success. The analysis revealed that SI participants are not significantly more likely to be successful in CHEM103 compared to non-participants, χ^2 (1, N = 42) = 2.69, p = .101.

MATH030 RESULTS

Descriptive Statistics

In MATH030, there were a total of 310 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 156 females (50%) and149 males (48%); 5 students did not disclose their gender (2%). Two-hundred and twelve students were non-participants (68%), while 52 students were LD participants (17%) and 46 students were High Dose participants (15%).

GPA. Students in the HD group (M = 2.40, SD = .76) had higher prior mean GPA's compared to those in the LD group (M = 2.24, SD = .84). Non-participants had a lower, preexisting mean GPA than both SI groups (M = 2.14, SD = .97).

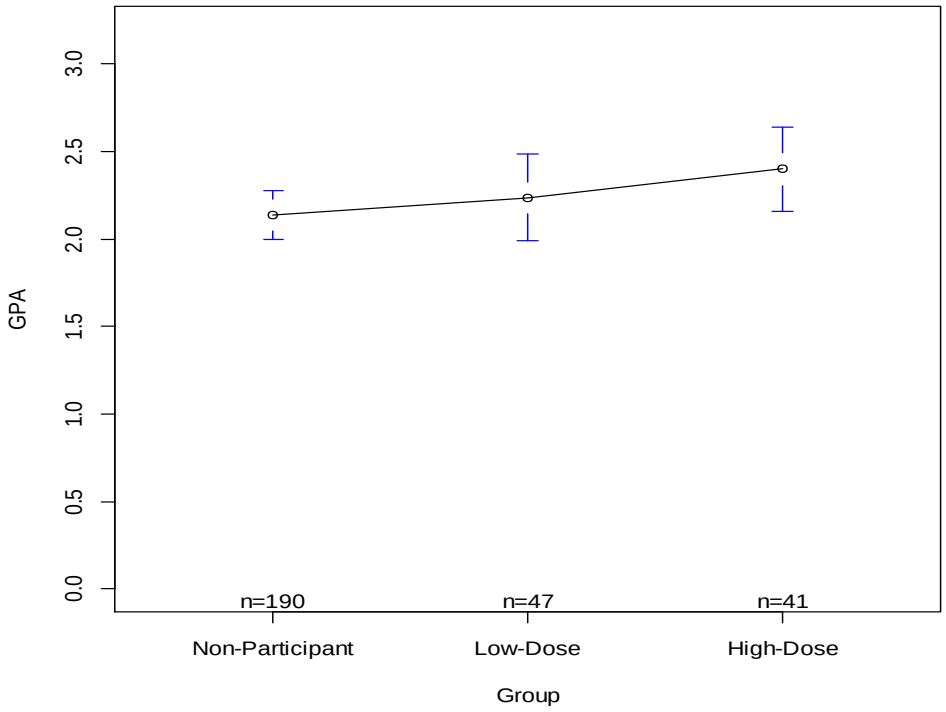

Figure 7. Preexisting GPA among SI groups

Success. Success rates were calculated for each SI group. Non-participants had a lower success rate (47%) then HD participants (52%) but higher success rate than LD participants (46%).

TABLE 6. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	100	112	212	47%
LDP	24	28	52	46%
HDP	24	22	46	52%
Total	148	162	310	48%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of GPA and SI participation on group success. The null model significantly improved after the inclusion of GPA χ^2 (1) = 22.01, $p < .001$. Success is expected to increase 0.65 logit units for a 1 unit increase in GPA, z (275) = 4.47, $p < .001$. The odds ratio reveals that as students GPA increased by a unit, the change in the odds of success is 1.92: students are more likely to be successful if their preceding GPA is high. The inclusion of SI participant variable did not significant improve the model fit, χ^2 (2) = 0.429, p =.81, such that LD SI participation does not significantly predict success, z (274) = -0.65, p =.51; moreover, HD participation did not significantly predict course success, z (274) = -0.13, p = .90.

TABLE 6.1- Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-1.47 (0.35)***	0.11	0.22	0.45
GPA	0.65 (0.14)***	1.45	1.92	2.59
LDP	-0.22 (0.34)	0.41	0.80	1.55
HDP	-0.05 (0.36)	0.47	0.96	1.93

Note. $p < .001$, *$p < .05$. **$p < .01$ ***$p < .001$

MATH032 RESULTS

Part I

Descriptive Statistics

In MATH032, there were a total of 127 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 66 females (53%) and158 males (47%); 3 students did not disclose their gender (2%). Seventy-two students were non-participants (57%), while 55 students were SI participants (43%).

Success. Success rates were calculated for each SI group. Non-participants had a much lower success rate (56%) then SI participants (78%).

TABLE 7. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	40	32	72	56%
SIP	43	12	55	78%
Total	83	44	127	65%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, SIP=SI participant

Inferential Test

A chi-square test was conducted to evaluate the association between non-participants and SI participants on success. The analysis revealed that SI participants are significantly more likely to be successful in MATH032 compared to non-participants, χ^2 (1, N = 127) = 6.09, p = .013.

MATH032 RESULTS

Part II

Descriptive Statistics

To further test the association between participation and success identified in Part I, several variables were included as possible confounders, including: gender, ethnicity, and prior GPA; all 127 students in MATH032 had a prior GPA. Participation was defined by three distinct groups (see Methods section, page 5).

GPA. Students in the HD group (M = 2.69, SD = .99) had higher prior mean GPA's compared to those in the LD group (M = 2.48, SD = 1.07). Non-participants had a lower, preexisting mean GPA than both SI groups (M = 2.33, SD = .99).

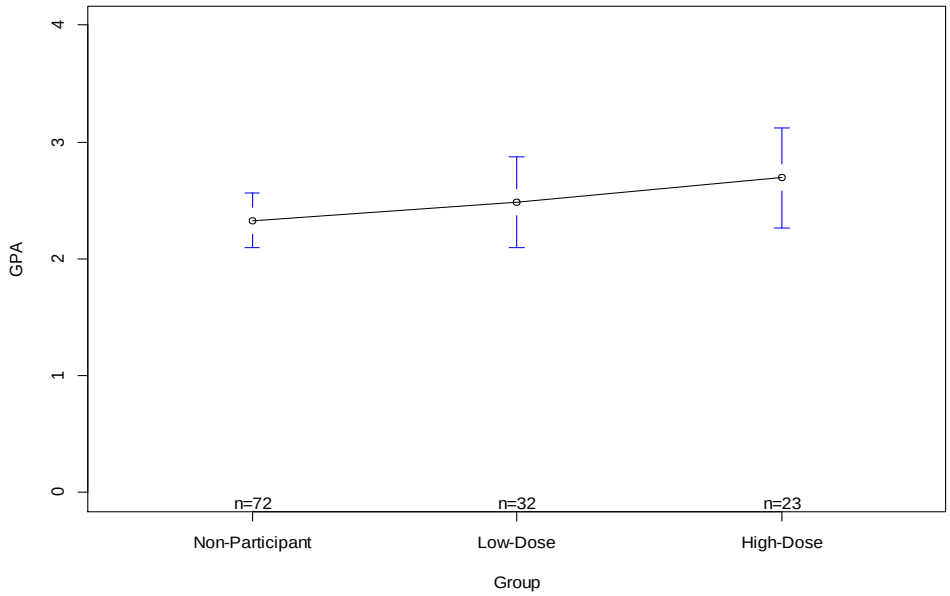

Figure 8. Preexisting GPA among SI groups

Success. Success rates were calculated for each SI group. Non-participants had the lowest success rate (56%), while those in the High-Does group had the highest (91%). It is interesting to note that there is a greater discrepancy between HD participants and LD participants (-22%) then there is between LD and non-participants (-13%).

TABLE 7.1 - Success Rates for SI Groups: LDP/HDP included

	Successful	Unsuccessful	Total	Success Rate[a]
NP	40	32	72	56%
LDP	22	10	32	69%
HDP	21	2	23	91%
Total	83	44	127	65%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of gender, ethnicity, GPA, and SI participation on group success. The null model did not significantly improve after the inclusion of gender χ^2 (1) = 2.17, p = .14; ethnicity did not significantly improve the model fit, χ^2 (3) = 2.73, p =.43. The model did however, significantly improve after the inclusion of GPA, χ^2 (1) = 26.42, p < .001, such that GPA significantly predicts success, z (116) = 4.23, p < .001. In addition, the odds ratio reveals that as students GPA increased by a unit, the change in the odds of success is 3.34: students are more likely to be successful if their preexisting, overall GPA is high.

After the inclusion of the abovementioned variables, the SI participant variable significantly improved the model fit, χ^2 (2) = 8.42, p =.01, such that HD SI participation significantly predicts success, z (116) = 2.47, p = .01, over and above gender, ethnicity, and GPA. In addition, the odds ratio reveals that as participation changes from non-participation to HD, the change in the odds of being successful compared to unsuccessful is 8.41: in other words, the odds of a HD participant being successful compared to being unsuccessful are 8.41 times the odds for a non-participant.

Table 7.2 - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-2.09 (.071)**	0.03	0.12	0.46
Male	-0.81 (0.48)	0.17	0.45	1.11
Asian	0.3 (1.21)	0.12	1.35	17.94
White	-0.82 (0.63)	0.12	0.44	1.52
Other Race	0.73 (0.89)	0.41	2.08	15.72
GPA	1.21 (0.29)***	1.99	3.34	6.16
LDP	0.58 (0.53)	0.64	1.78	5.27
HDP	2.13 (0.86)*	1.86	8.41	62.73

Note. p < .001, *p < .05. **p < .01 ***p < .001

MATH142 RESULTS

Descriptive Statistics

In MATH030, there were a total of 101 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 52 females (51%) and 47 males (47%); 2 students did not disclose their gender (2%). Thirty-eight students were non-participants (38%), while 28 students were LD participants (28%) and 35 were HD participants (35%).

GPA. Ninety-five students had a preexisting GPA in MATH142. Students in the HD group (M = 2.87, SD = .71) had marginally higher prior mean GPA's compared to those in the LD group (M = 2.82, SD = .75). Non-participants had a lower, preexisting mean GPA than both SI groups (M = 2.40, SD = .93).

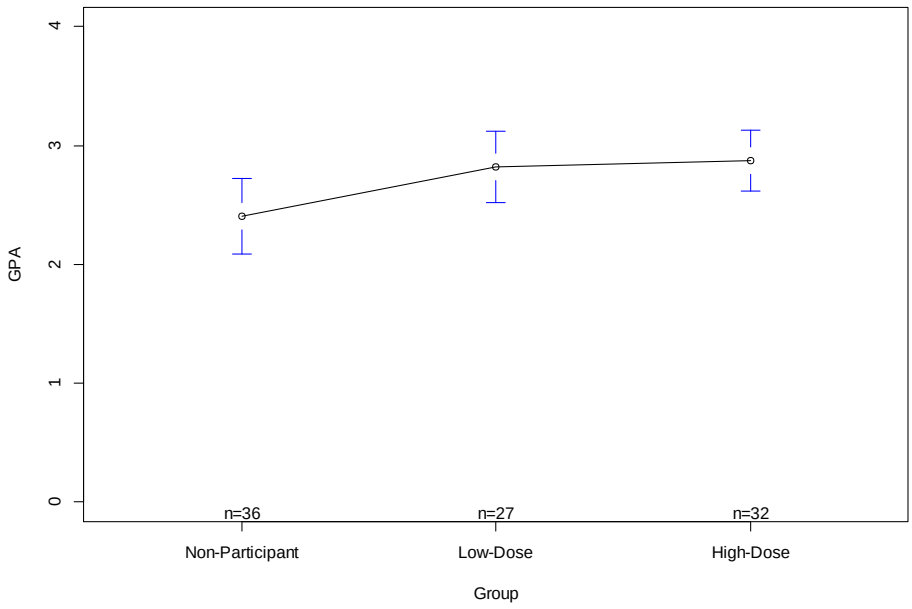

Figure 9. Preexisting GPA among SI groups

Success. Success rates were calculated for each SI group. Non-participants had the lowest success rate (50%). Students in the HD group were marginally more successful than those in the LD group (74% to 71%).

TABLE 8. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	19	19	38	50%
LDP	20	8	28	71%
HDP	26	9	35	74%
Total	65	36	101	64%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of GPA and SI participation on course success. The null model significantly improved after the inclusion of GPA χ^2 (1) = 28.78, $p < .001$, such that GPA significantly predicts success, z (91) = 3.89, $p < .001$. In addition, the odds ratio reveals that as students GPA increased by a unit, the change in the odds of success is 5.81: students are more likely to be successful if their preexisting, overall GPA is high.

The model did not, however, significantly improve after the inclusion of the SI participant variable, χ^2 (2) = 2.22, $p = .33$. LD participation did not significantly predict course success, z (91) = 1.04, $p = .30$; moreover, HD participation did not significantly predict course success, z (91) = 1.40, $p = .16$.

Table 8.1 - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-4.25 (1.16)***	0.00	0.01	0.11
GPA	1.76 (0.45)***	2.62	5.81	15.76
LDP	0.67 (0.64)	0.56	1.95	7.13
HDP	0.86 (0.61)	0.72	2.36	8.15

Note. $p < .001$, *$p < .05$. **$p < .01$ ***$p < .001$

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

MATH150 RESULTS

Descriptive Statistics

In MATH150, there were a total of 405 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 227 females (56%) and 170 males (42%); 8 students did not disclose their gender (2%). Two-hundred and fifty-six students were non-participants (63%), while 80 students were LD participants (20%) and 69 were HD participants (17%).

GPA. Three-hundred and eighty-eight students had a preexisting GPA in MATH150. Students in the HD group (M = 2.88, SD = .61) had a noticeably higher prior mean GPA compared to those in the LD group (M = 2.63, SD = .61). Non-participants had a lower, preexisting mean GPA compared to both SI groups (M = 2.54, SD = .78).

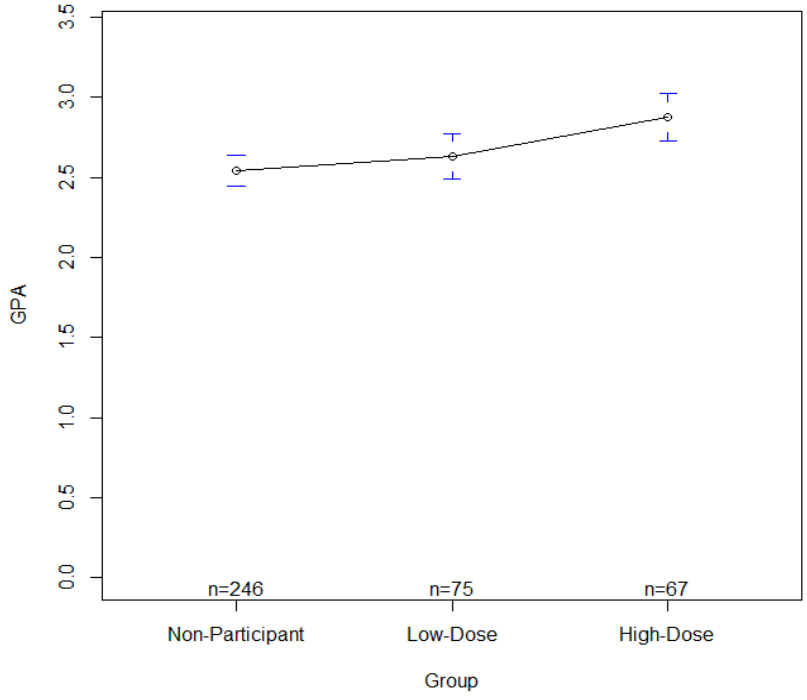

Figure 10. Preexisting GPA among SI groups

Success. Success rates were calculated for each SI group. LD participants had the lowest success rate (61% compared to non-participants 64%). Students in the HD group were proportionally the most successful group (77%).

TABLE 9. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	164	92	256	64%
LDP	49	31	80	61%
HDP	53	16	69	77%
Total	266	139	405	66%

Note. Students earning a final grade "W" and students with gender Not Disclosed included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of GPA and SI participation on course success. The null model significantly improved after the inclusion of GPA χ^2 (1) = 23.07, $p < .001$, such that GPA significantly predicts success, z (384) = 4.40, $p < .001$. In addition, the odds ratio reveals that as students GPA increased by a unit, the change in the odds of success is 2.04: students are more likely to be successful if their preexisting, overall GPA is high.

The model did not, however, significantly improve after the inclusion of the SI participant variable, χ^2 (2) = 1.89, $p = .61$. LD participation did not significantly predict course success, z (384) = -0.58, $p = .56$; moreover, HD participation did not significantly predict course success, z (384) = 1.07, $p = .29$.

Table 9.1 - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-1.11 (0.42)**	0.14	0.33	0.74
GPA	0.71 (0.16)***	1.49	2.04	2.82
LDP	-0.16 (0.28)	0.49	0.85	1.49
HDP	0.36 (0.33)	0.72	1.43	2.81

Note. $p < .001$, *$p < .05$. **$p < .01$ ***$p < .001$

*NP = Non-Participant, LDP = LD Participant, HDP = HD Participant

MATH151 RESULTS

Descriptive Statistics

In MATH151, there were a total of 38 students who earned a final grade for the spring 2015 semester. The gender breakdown consisted of 13 females (34%) and 25 males (66%). Twenty-three students were non-participants, while 15 students were SI participants (students who attended at least 1 SI session).

Success. Success rates were calculated for each SI group. Non-participants and SI participants had nearly identical success rates, with only a 3% difference for participants (30% to 33%). Success rates for both groups were exceptionally low due to the uncharacteristically large quantity of students who withdrew (received a final grade of W) from the course; 9 non-participants and 4 participants received W's.

TABLE 10. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	7	16	23	30%
SIP	5	10	15	33%
Total	12	26	38	32%

Note. Students earning a final grade "W" included in calculation of Success Rate

[a]Success rate = number successful/Total*100

*NP = Non-Participant, SIP=SI participant

Inferential Test

A chi-square test was conducted to evaluate the association between SI participants and non-participants on success. The analysis revealed that SI participants are not significantly more likely to be successful in MATH151 compared to non-participants, χ^2 (1, N = 38) = 0.35, p = .85.

DISCUSSION

Supplemental Instruction continues to be implemented as a mechanism to improve student course outcomes. In previous studies, SI has been found to be advantageous in assisting students to be more successful in their semester course; however, disjointed congruency among study design and analysis raise methodological questions. Notwithstanding the apprehensions from a research perspective, the lack of a cohesive SI adjudication functions as problematic for educational practitioners designing and implementing interventions. The findings of this study contribute to higher education literature on the effects of SI within the framework of STEM. Results indicate that GPA remains the strongest indicator of how well a student will perform; in fact, across the spectrum of courses investigated in this study, GPA yielded a significant, positive effect in every analysis in which it was included. SI group membership was significantly associated with student success in 3 out of 9 analyses, exclusive to BIOL105 and MATH032; only in MATH032 was SI participation significant in the presence of GPA; specifically, success was more likely for HD participants. In BIOL105, HD participants were more likely to not be unsuccessful than LD participants and non-participants. However, the number of SI sessions attended does not significantly predict a better final grade in the presence of GPA.

SI Participation and Success

Due to the vastness of this study and the inconsistency of SI research, aspects of these findings are both comparable and divergent to the current literature regarding SI and student success. For instance, a study found that SI positively affects student success in STEM, as did the present study; however, there was no distinction in success between ethnicities, as identified by Meiling et al, (2013). Additionally, relating the findings of the same study with that of the current, significant differences were not demonstrated among participants in chemistry, which detour from what was previously found (Meiling et al, 2013). Notwithstanding the contrary findings, results of this study also correlate with literature indicating a greater impact of SI among courses designated earlier in a sequence. More explicitly, SI does not show effectiveness when courses demand increased prior knowledge from students (Rath et al, 2011). This was most expressively identified in MATH150 and MATH142, where despite an adequate sample size in each course, SI participation failed to predict success; yet, in MATH032 SI participation was demonstrated as significantly predicting course success, over and above preexisting GPA.

Future Research

Future research should begin to expound upon the methodology previously utilized for SI study design and evaluations. Therefore, two primary suggestions to further test the effectiveness of SI are proposed. The first is to design and implement a randomized control trial investigating

the efficacy of SI exposure against a standard level intervention, such as a fundamental tutoring service. Randomization would adequately compare "SI seekers" against themselves and isolate the true impact of SI; such a design maintains the ability to usher in clarity among the fragmented SI literature. The second is to increase the usage of more appropriate statistical analysis for evaluations. For example, researchers should carefully determine the operationalization of outcome variables in regression analysis, as well as consider centered predictors, standardization, and Poisson models where appropriate. In addition, statistical models should not omit preexisting, overall GPA as a proxy for scholastic aptitude; doing so could provide misleading results regarding the efficacious ability of SI. Therefore, it would enrich the education literature to move beyond the over-simplification of associations and increase statistical rigor and scrutiny when evaluating SI.

Study Limitations

Several limitations are present to the current study. One limitation to this study is the locale in which it took place (one campus); the generalizability of SI findings would be enhanced by a cross-campus examination. Additionally, variations in teaching ability among SI leaders may be present and therefore impacting the comparability between sections and courses. Another restraint of this study includes the lack of longitudinal data. Growth curves could provide insight into not only other efficacious aspects of SI (i.e., persistence), but also enable examination of SI's role in changes within students GPA over time. Moreover, surveillance over performance data through a linear course sequence would strengthen the supposition of SI's limited lower level course effectiveness. Lastly, extraneous variables may exist such as individual variation in student ability, home/work life, and other personal factors left unmeasured in the current study that also may account for some of the variability in student academic outcomes.

Conclusion

Although limitations were identified, the current study maintains several facets that ensure findings can be interpreted with certainty. First, as identified by Grove et al (2006), the inclusion of preexisting, overall GPA controls for student ability and motivation, enabling the findings to be interpreted over and above a key variable in academic success. Also, this study omitted the use of Ordinary Least Squares (OLS) regression for logistic analysis more suitable of the intrinsic nature of outcome variables. Lastly, this study examined SI at separate, more discrete doses, which delimited the contamination and over-inflation of the non-participant pool. The results indicate that SI can be efficacious in some low-level courses at high-doses.

APPENDIX

Success and Participation Rates

The participation and success rates indicated in the table below reflect the spring 2015 semester using the same participant designation utilized in previous semester evaluations of SI. A student is considered a participant if they attended ≥5 SI sessions throughout the semester. This table has been included for the readers ease in making success and participation comparisons across semester reports; however, the participant classification in the table does not reflect the participant classification used in this study.

TABLE A. Enrollment and success rates (Withdraw students included)

	Enrollment	Participation		Participation Rates	Success Rates	
		<5	≥5		Non-Participants	Participants
BIOL105	797	670	127	16%	69%	87%
CHEM103	42	36	6	14%	83%	100%
MATH030	310	264	46	15%	47%	52%
MATH032	127	104	23	18%	60%	91%
MATH142	101	66	35	35%	59%	74%
MATH150	405	336	69	17%	63%	77%
MATH151	38	26	12	32%	31%	33%
Total	1820	1502	318	17%	63%	77%

REFERENCES

Rath, K. A., Peterfreund, A., Bayliss, F., Runquist, E., & Simonis, U. (2011). Impact of supplemental instruction in entry-level chemistry courses at a midsized public university. *Journal of Chemical Education*, 89(4), 449-455.

Meling, V. B., Mundy, M. A., Kupczynski, L., & Green, M. E. (2013). Supplemental instruction and academic success and retention in science courses at a Hispanic-serving institution. *World Journal of Education*, 3(3), p11.

Dawson, P., van der Meer, J., Skalicky, J., & Cowley, K. (2014). On the Effectiveness of Supplemental Instruction: A systematic review of supplemental instruction and peer-assisted study sessions literature between 2001 and 2010. *Review of Educational Research*, *84*(4), 609-639.

Oja, M. (2012). Supplemental instruction improves grades but not persistence. *College Student Journal*, 46(2), 344.

Grove, W. A., Wasserman, T., & Grodner, A. (2006). Choosing a proxy for academic aptitude. *The Journal of Economic Education*, *37*(2), 131-147.

Bowles, T.J., Jason, J. (2004). An analysis of the effectiveness of supplemental instruction: the problem of selection bias and limited dependent variables. J*ournal of College Student Retention*, 5(2), 235-243