SUPPLEMENTAL INSTRUCTION EFFECTIVENESS REPORT

FALL 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 six different math and science courses while controlling for demographic and academic aptitude variables. Students (N = 1,543) were separated into three groups based on their SI attendance, including a Low-Dose SI group (n = 403), a High-Dose SI group (n = 265) and non-participant group (n = 875). Participants in the Low-Dose group consisted of students who attended SI between 1-4 times, while participants in the High-Dose group consisted of students who attended SI five or more times. Success outcomes were compared across courses and between groups.

For all courses, High-Dose participants showcased higher success rates than their Low-Dose and non-participant counterparts. In several courses, the differences between group success rates were greater between High-Dose participants and Low-Dose participants than between Low-Dose and non-participants. Statistical analysis revealed that individuals with higher preexisting or higher concurrent semester GPA's are more likely to succeed, regardless of their level of participation. Additionally, a student's score on the Accuplacer Math test was identified as significantly predicting success in the two lowest level math courses in this study. SI did not significantly predict success in any analysis. These findings suggest that the greatest predictive variable of an individual student's success in a math and science course is their preexisting GPA.

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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 when evaluating the effects of SI on course outcomes. 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 fall 2015 semester. This study aims to test the hypothesis that SI positively effects course success by comparing SI users against non-users. 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 fall 2015 semester across 50 sections of six math and core science courses supported by SI (***N*** = 1,543). These courses consist of BIOL105, MATH029, MATH030, MATH032, MATH142, and MATH150. 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 fall 2015 semester.

TABLE 1. Course Enrollment

Course	Enrollment	Sections Supported by SI
BIOL105	572	24
MATH029	150	5
MATH030	277	7
MATH032	90	3
MATH142	74	2
MATH150	380	9
Total	1,543	50

Demographic Characteristics

The gender breakdown consisted of 632 males (41%), 876 (57%) females, and 35 students who did not disclose gender (2%). The majority of students were Hispanic (66%), while 16% 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 fall 2015 semester (see figure 2 and table 2).

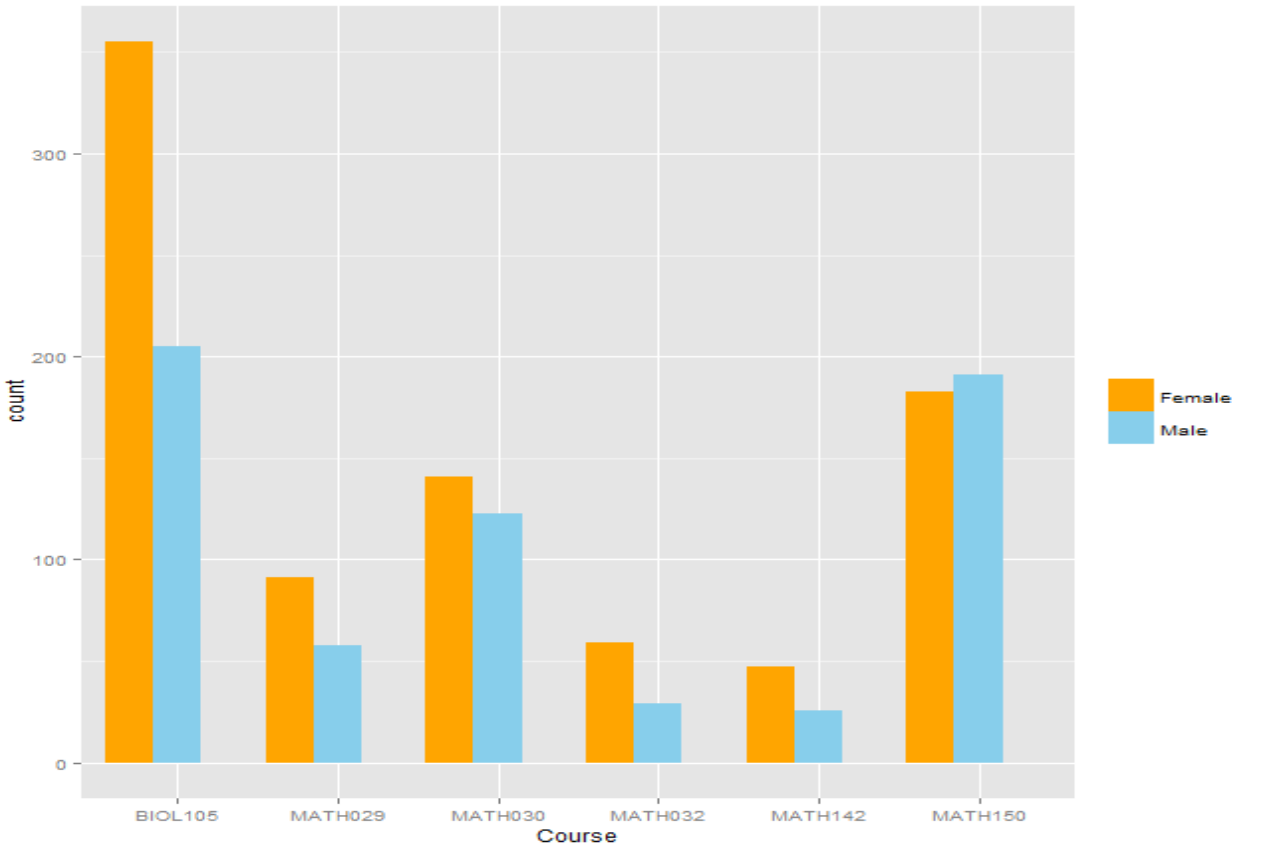

FIGURE 1. Gender distribution by course. Females are more prevalent in every course except MATH150.

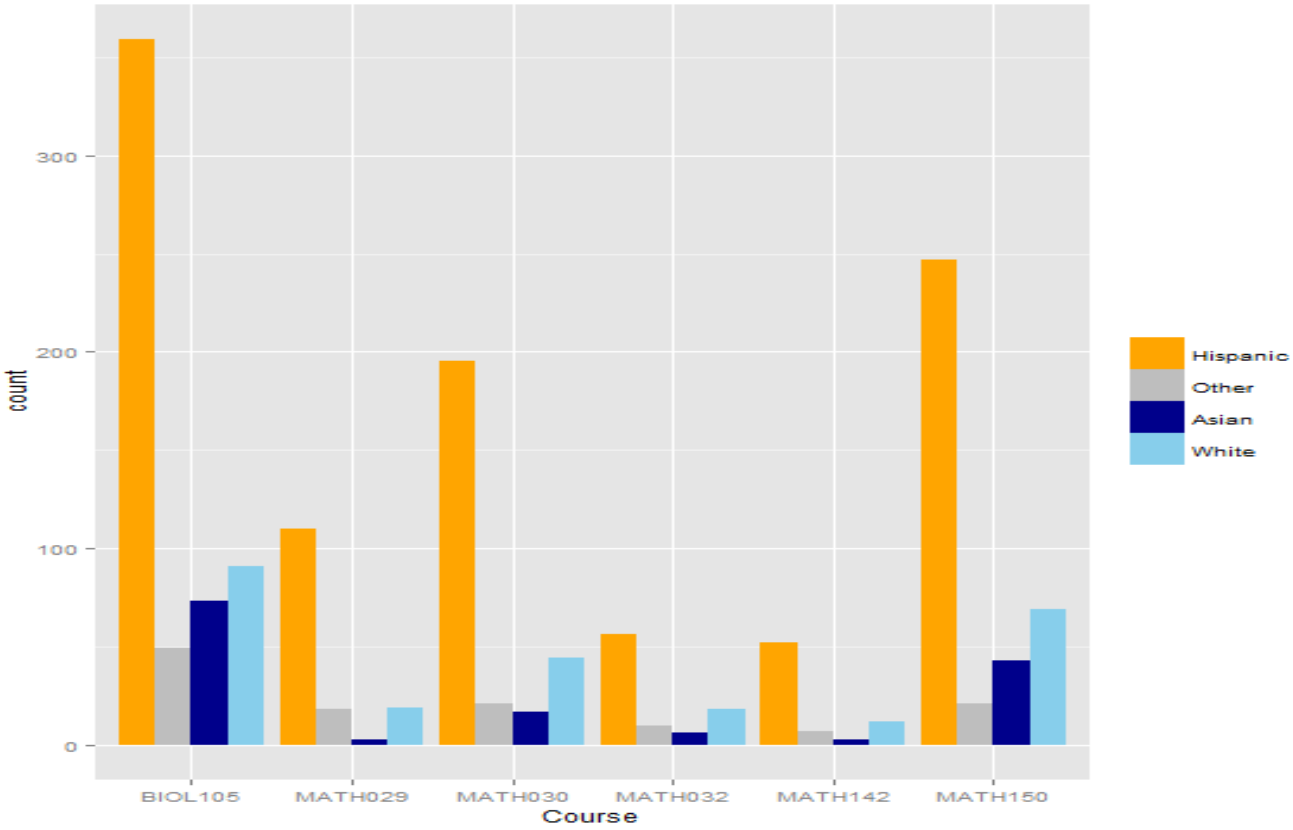

FIGURE 2. Ethnicity distribution by course. Hispanics are most prevalent in every course.

TABLE 2. Group proportions by ethnicity and course

	Hispanic			Other			Asian			White			Total			
	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	Total
BIOL105	38%	16%	9%	6%	2%	1%	8%	3%	1%	11%	3%	2%	63%	24%	13%	100%
MATH029	41%	21%	11%	3%	5%	4%	1%	1%	0%	8%	1%	4%	53%	27%	19%	100%
MATH030	42%	17%	12%	4%	1%	3%	3%	3%	1%	9%	3%	4%	57%	23%	19%	100%
MATH032	23%	22%	17%	7%	1%	3%	4%	2%	0%	11%	6%	3%	46%	31%	23%	100%
MATH142	23%	24%	23%	7%	1%	1%	4%	0%	0%	7%	4%	5%	41%	30%	30%	100%
MATH150	33%	20%	12%	3%	2%	1%	7%	3%	1%	11%	5%	3%	53%	29%	17%	100%

*NP = Non-Participant, LDP = Low-Dose Participant, HDP = High-Dose 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 MATH029 (HDP = 10% to 9%).

TABLE 3. Group proportions by gender and course

	Male			Female			Total			
	NP	LDP	HDP	NP	LDP	HDP	NP	LDP	HDP	Total
BIOL105	23%	9%	5%	40%	15%	8%	63%	24%	13%	100%
MATH029	21%	7%	10%	32%	19%	9%	54%	27%	19%	100%
MATH030	28%	11%	7%	29%	12%	13%	58%	23%	19%	100%
MATH032	17%	9%	7%	28%	22%	17%	45%	31%	24%	100%
MATH142	18%	7%	11%	23%	23%	18%	41%	30%	29%	100%
MATH150	32%	11%	8%	21%	18%	9%	53%	29%	17%	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 fall 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 corresponding 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 (n = 35).

Ethnicity. An ethnicity variable was dummy coded designating Hispanics as the reference group. Due to an extremely low frequency of 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.

GPA and SEMGPA-"Course". Collegiate GPA has been identified as the best proxy for student academic aptitude (Grove, Wasserman, & Grodner, 2006). In this study, GPA represents a student's preexisting (before fall 2015), overall GPA. Data were acquired using the Citrus College local database Banner and obtained prior to the end of the fall 2015 semester; thus, the data for GPA do not include that which was completed in the fall 2015 semester. SEMGPA-"Course" represents a student's semester GPA minus the grade for the class in which success is to be predicted. This variable is used when there are a large number of students without a preexisting GPA and has been shown to be a strong representation of academic ability (Grove et al, 2006).

AccuMath. Students' scores on the Accuplacer Math test was included as a covariate in this study. This variable was not collinear with GPA and therefore included in the model to control for another facet of student academic aptitude (Grove et al, 2006).

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 = 875), Low-Dose participants (n = 403), and High-Dose participants (n = 265). Low-Dose participants were defined as students who had attended an SI session 1 - 4 times

throughout the semester and High-Dose participants 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.

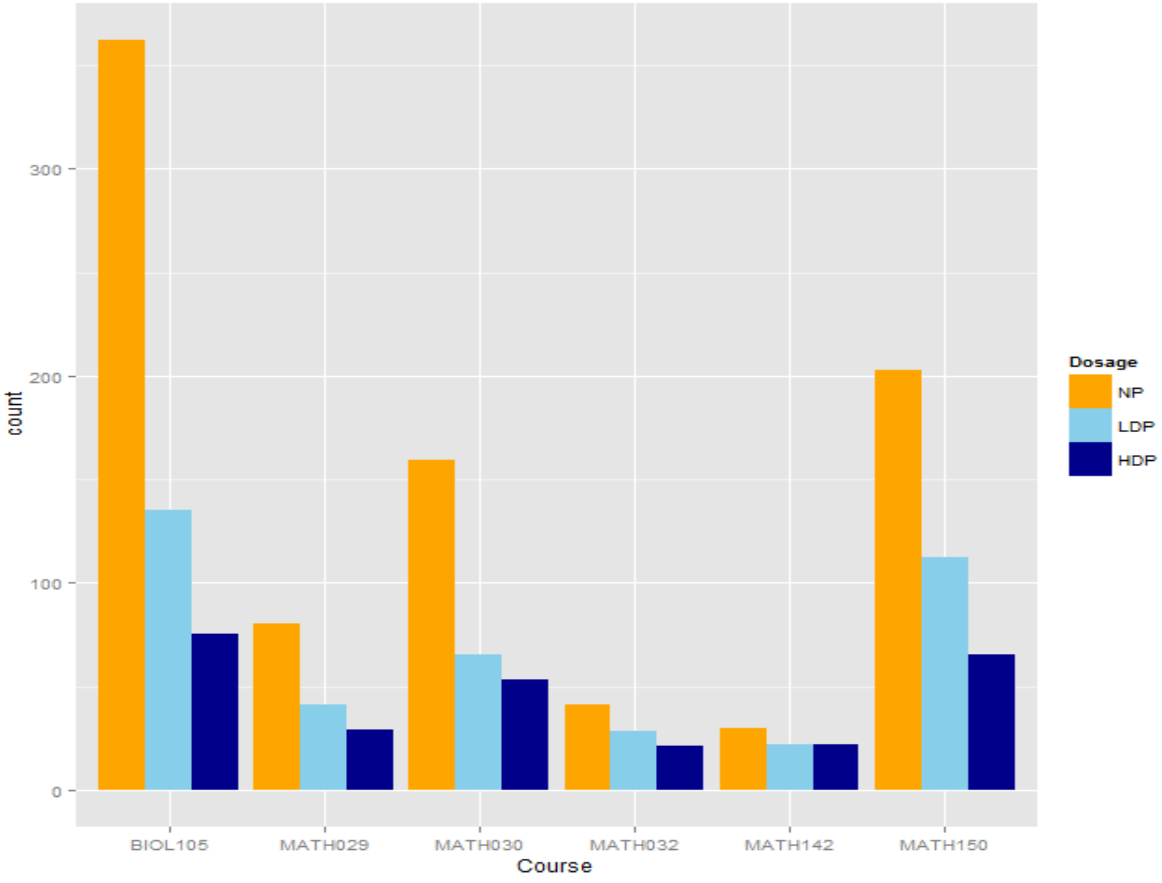

FIGURE 3. SI group distribution by course. Exceedingly more Non-participants than Low-Dose and High-Dose participants are observed for most courses except when the overall course size is exceptionally low, such as MATH032 and MATH142.

Analytic Strategy

All analyses were performed and graphs constructed using statistical package R version 3.1.3. Considering the dynamics of each course separately, different variables 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. All courses were evaluated using a binomial logistic regression model where course success was predicted by GPA, AccuMath score, Ethnicity, and SI participation. The model below depicts the full model used in most analyses (some courses were evaluated omitting ethnicity to accommodate sample size restrictions; additionally, the BIOL105 analysis did not include AccuMath scores as a predictor). Every course was inferentially tested at the 0.05 α level.

Full Model:

$$P(Success) = \frac{1}{1+e^{-(b0+b1GPA+b2AccuMath+b3Other+b4Asian+b5White+b6LDP*b7HDP+e)}}$$

BIOL105 RESULTS

Descriptive Statistics

In BIOL105, there were a total of 572 students who earned a final grade for the fall 2015 semester. The gender breakdown consisted of 355 females (62%), 205 males (36%), and 12 students who did not disclose their gender (2%). Non-participants made up 63% of the course total, Low-Dose participants made up 24% of the total, and High-Dose participants, who were the smallest group, consisted of 13% of the total number of students enrolled in BIOL105. Table 4 shows the descriptive statistics of preexisting GPA by participation group.

TABLE 4. Preexisting GPA

	M	*SD*	*Var*	*Min*	*Max*
NP	2.62	0.81	0.66	0	4
LDP	2.70	0.79	0.62	0	4
HDP	2.80	0.72	0.52	0	4

Success. Success rates were calculated for each SI group. Non-participants had the lowest success rate (67%), while High-Dose participants showcased the highest success rate (84%); 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 High-Dose participants and Low-Dose participants (-14%) than there is between Low-Dose participants and Non-participants (-3%).

TABLE 4.1. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	243	119	362	67%
LDP	94	41	135	70%
HDP	63	12	75	84%
Total	400	172	572	70%

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 = Low-Dose Participant, HDP = High-Dose Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of GPA, ethnicity, and SI participation on group success. The null model significantly improved after the inclusion of GPA χ^2 (1) = 69.36, $p < .001$, such that GPA significantly predicts success, z (477) = 7.31, $p < .001$. The model did not significantly improve after the inclusion of Ethnicity, χ^2 (3) = 1.05, $p = .789$.

After accounting for the abovementioned variables, the SI participant variable was added in the final sequential step and did not significantly improve the model fit, χ^2 (2) = 2.88, $p = .237$, such that Low-Dose SI participation does not significantly predict success z (472) = 0.74, $p = .457$ and High-Dose SI participation does not significantly predict success, z (472) = 1.59, $p = .112$. Alternatively, GPA remained significant and the odds ratio reveals that as students GPA increased by a unit, the change in the odds of success is 3.11: students are more likely to be successful if their preexisting, overall GPA is high.

TABLE 4.2. - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-2.21 (.041)***	0.05	0.11	0.24
GPA	-1.13 (0.16)***	2.30	3.11	4.30
Other	0.31 (.43)	0.60	1.36	3.28
Asian	-0.18 (0.35)	0.42	0.83	1.69
White	0.07 (0.31)	0.59	1.07	2.01
LDP	0.19 (0.26)	0.74	1.21	2.02
HDP	0.58 (0.37)	0.90	1.79	3.82

Note. R^2 = .004 (Hosmer-Lemeshow), .14 (Cox-Snell), .20 (Nagelkerke). Model $\chi^2(2)$ = 2.88, p > .05 ***$p < .001$

MATH029 RESULTS

Descriptive Statistics

In MATH029, there were a total of 150 students who earned a final grade for the fall 2015 semester. The gender breakdown consisted of 91 females (61%) and 58 males (39%); one student did not disclose their gender. Eighty students were non-participants, while 41 students were Low-Dose participants (27%) and 29 students were High-Dose participants (19%). Table 5 shows the descriptive statistics for SEMGPA-MATH029 and AccuMath score by participation group.

TABLE 5. SEMGPA & AccuMath Score

	SEMGPA - MATH029					AccuMath Score				
	M	*SD*	*Var*	*Min*	*Max*	*M*	*SD*	*Var*	*Min*	*Max*
NP	1.70	1.21	1.46	0.00	4.00	2002.75	0.65	0.42	2002.00	2005.00
LDP	2.29	1.49	2.21	0.00	4.00	2002.73	0.67	0.45	2002.00	2005.00
HDP	3.04	1.17	1.37	0.00	4.00	2002.69	0.89	0.79	2002.00	2005.00

Success. Success rates were calculated for each SI group. Non-participants and Low-Dose participants had equal success rates (61%) while the High-Dose group saw a substantially greater proportion of individuals as successful (86%).

TABLE 5.1. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	49	31	80	61%
LDP	25	16	41	61%
HDP	25	4	29	86%
Total	99	51	150	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 = Low-Dose Participant, HDP = High-Dose Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of SEMGPA-MATH029, AccuMath score, ethnicity, and SI participation on group success. The null model significantly improved after the inclusion of SEMGPA-MATH029 χ^2 (11) = 40.18, $p < .001$, such that SEMGPA-MATH029 significantly predicts success, z (138) = 4.44, $p < .001$; as does AccuMath score, z (138) = 2.85, $p < .01$.

After accounting for the abovementioned variables, the SI participant variable was added in the final sequential step and did not significantly improve the model fit, χ^2 (2) = 3.13, $p = .208$, such that Low-Dose SI participation does not significantly predict success, z (133) = -0.25, p = 804 and High-Dose SI participation does not significantly predict success, z (133) = 1.49, p = .137. Alternatively, SEMGPA-MATH029 remained significant and the odds ratio reveals that as students SEMGPA-MATH029 increased by a unit, the change in the odds of success is 1.82: students are more likely to be successful in MATH029 if they earned high marks in other classes during the concurrent semester. For AccuMath score, the odds ratio reveals that as students AccuMath scores increased by a unit, the change in the odds of success is 2.67: students are more likely to be successful if they have scored high on the Accuplacer Math test.

TABLE 5.2. - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-1,970 (.739.73)**	0.00	0.00	0.00
SEMGPA-MATH029	0.60 (0.17)***	1.32	1.82	2.57
AccuMath	0.98 (.37)**	1.34	2.67	5.74
Other	-0.14 (.62)	0.25	0.87	3.03
Asian	16.43 (1,306.60)	-	-	-
White	1.97 (1.14)	1.12	7.19	146.01
LDP	-0.12 (0.49)	0.33	0.89	2.31
HDP	1.07 (0.72)	0.76	2.93	13.50

Note. R^2 = .017 (Hosmer-Lemeshow), .28 (Cox-Snell), .37 (Nagelkerke). Model $\chi^2(2) = 3.14$, p > .05, ***$p <$ .001, ** p < .01

MATH030 RESULTS

Descriptive Statistics

In MATH030, there were a total of 277 students who earned a final grade for the fall 2015 semester. The gender breakdown consisted of 141 females (51%) and 123 males (44%); 13 students did not disclose their gender (5%). One-hundred and fifty-nine were non-participants (57%), while 65 students were Low-Dose participants (23%) and 53 students were High-Dose participants (19%). Table 6 shows the descriptive statistics for SEMGPA-MATH030 and AccuMath score by participation group.

TABLE 6. SEMGPA & AccuMath Score

	SEMGPA - MATH030					AccuMath Score				
	M	*SD*	*Var*	*Min*	*Max*	*M*	*SD*	*Var*	*Min*	*Max*
NP	1.94	1.25	1.56	0.00	4.00	2003.63	0.77	0.59	2002.00	2006.00
LDP	2.23	1.06	1.13	0.00	4.00	2003.32	0.88	0.77	2002.00	2005.00
HDP	2.60	1.16	1.35	0.00	4.00	2003.41	0.96	0.93	2002.00	2006.00

Success. Success rates were calculated for each SI group. Non-participants had the lowest success rate (50%), though Low-Dose participants were not substantially greater (55%). High-Dose participants had the highest success rate (64%).

TABLE 6.1. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	80	79	159	50%
LDP	36	29	65	55%
HDP	34	19	53	64%
Total	150	127	277	54%

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 = Low-Dose Participant, HDP = High-Dose Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of SEMGPA-MATH030, AccuMath score, ethnicity, and SI participation on group success The null model significantly improved after the inclusion of GPA and AccuMath χ^2 (2) = 59.22, $p < .001$, such that SEMGPA-MATH030 significantly predicts success, z (259) = 6.76, $p < .001$; as does AccuMath score, z (259) = 2.10, $p < .05$.

The inclusion of SI participant variable did not significant improve the model fit, χ^2 (2) = 0.358, p =.84, such that Low-Dose SI participation does not significantly predict success, z (254) = 0.19, p =.59; moreover, High-Dose participation did not significantly predict course success, z (254) = 0.15, p = .70. Alternatively, SEMGPA-MATH030 remained significant and the odds ratio reveals that as students SEMGPA-MATH030 increased by a unit, the change in the odds of success is 2.40: students are more likely to be successful in MATH030 if they earned high marks in other classes during the concurrent semester. For AccuMath score, the odds ratio reveals that as students AccuMath scores increased by a unit, the change in the odds of success is 1.45: students are more likely to be successful if they have scored high on the Accuplacer Math test.

TABLE 6.2.- Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-747.38 (350.42)*	0.00	0.00	0.00
SEMGPA-MATH030	0.88 (0.13)***	1.87	2.40	3.16
AccuMath	0.37 (0.17)*	1.03	1.45	2.06
Other	0.23 (0.54)	0.43	1.26	3.72
Asian	-0.04 (0.65)	0.27	0.96	3.67
White	0.05 (0.40)	0.48	1.06	2.36
LDP	0.19 (0.34)	0.62	1.21	2.38
HDP	0.15 (0.40)	0.54	1.17	2.58

Note. R^2 = .00099 (Hosmer-Lemeshow), .20 (Cox-Snell), .27 (Nagelkerke). Model $\chi^2(2) = .36$, $p > .05$, ***$p < .001$, * $p < .05$

MATH032 RESULTS

Descriptive Statistics

In MATH032, there were a total of 90 students who earned a final grade for the fall 2015 semester. The gender breakdown consisted of 59 females (66%) and 29 males (32%); 2 students did not disclose their gender (2%). Forty-one students were non-participants (46%), while 28 students were Low-Dose participants (31%) and 21 students were High-Dose participants (23%). Table 7 shows the descriptive statistics for SEMGPA-MATH032 and AccuMath score by participation group.

TABLE 7. SEMGPA & AccuMath Score

	SEMGPA - MATH032					AccuMath Score				
	M	*SD*	*Var*	*Min*	*Max*	*M*	*SD*	*Var*	*Min*	*Max*
NP	1.40	1.32	1.74	0.00	3.50	2003.05	0.89	0.80	2002.00	2005.00
LDP	2.65	1.28	1.65	0.00	4.00	2003.39	0.92	0.84	2002.00	2005.00
HDP	3.10	0.95	0.89	1.00	4.00	2002.95	0.92	0.85	2002.00	2005.00

Success. Success rates were calculated for each SI group. Low-Dose participants (61%) had a lower success rate than non-participants (66%) and a much lower success rate then High-Dose participants (90%).

TABLE 7.1. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	27	14	41	66%
LDP	17	11	28	61%
HDP	19	2	21	90%
Total	63	27	90	70%

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 = Low-Dose Participant, HDP = High-Dose Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of, SEMGPA-MATH032, AccuMath score, ethnicity and SI participation on group success. The null model significantly improved after the inclusion of SEMGPA-MATH032 and AccuMath χ^2 (2) = 6.45, $p < .05$, such that SEMGPA-MATH032 significantly predicts success, z (77) = 2.46, $p < .05$; AccuMath score did not significantly predict success, z (77) = -.821, $p > .05$. Ethnicity also significantly improved the model fit, χ^2 (3) = 9.09, $p < .05$, such that being white significantly predicts success, (74) = 2.34, $p < .05$.

After the inclusion of the abovementioned variables, the SI participant variable did not significantly improve the model fit, χ^2 (2) = 4.46, p =.107, such that Low-Dose SI participation does not significantly predict success, z (72) = -0.87, p = .39; moreover, High-Dose participation did not significantly predict course success, z (72) = 1.30, p = .19. Alternatively, SEMGPA-MATH032 remained significant and the odds ratio reveals that as students SEMGPA-MATH032 increased by a unit, the change in the odds of success is 1.73: students are more likely to be successful in MATH032 if they earned high marks in other classes during the concurrent semester.

TABLE 7.2.- Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	317.62 (648.70)	0.00	-	-
SEMGPA-MATH032	-0.55 (0.24)*	1.11	1.73	2.82
AccuMath	-0.16 (0.32)	0.45	0.85	1.62
Other	-0.11 (0.82)	0.18	0.90	4.73
Asian	0.56 (1.05)	0.24	1.75	16.91
White	2.73 (1.16)*	2.29	15.41	319.32
LDP	-0.60 (0.69)	0.13	0.55	2.08
HDP	1.19 (0.92)	0.61	3.30	25.85

Note. R^2 = .04 (Hosmer-Lemeshow), .22 (Cox-Snell), .31 (Nagelkerke). Model $\chi^2(2) = 4.47$, p > .05, ***p < .001, * p < .05

MATH142 RESULTS

Descriptive Statistics

In MATH142, there were a total of 74 students who earned a final grade for the fall 2015 semester. The gender breakdown consisted of 47 females (64%) and 26 males (35%); 1 student did not disclose their gender (1%). Thirty students were non-participants (40%), while 22 students were Low-Dose participants (30%) and 22 were High-Dose participants (30%). Table 8 shows the descriptive statistics for preexisting GPA and AccuMath score by participation group.

TABLE 8. Preexisting GPA & AccuMath Score

	Preexisting GPA					AccuMath Score				
	M	*SD*	*Var*	*Min*	*Max*	*M*	*SD*	*Var*	*Min*	*Max*
NP	2.45	0.62	0.38	1.39	4.00	2003.13	1.11	1.22	2001.00	2005.00
LDP	2.41	0.63	0.40	1.46	3.83	2003.09	1.06	1.13	2001.00	2005.00
HDP	2.96	0.66	0.44	1.71	4.00	2002.91	1.02	1.04	2002.00	2005.00

Success. Success rates were calculated for each SI group. Low-Dose participants had the lowest success rate (41%), while still low, the non-participants had a higher success rate than the Low-Dose students (53%). Students in the High-Dose group were much more successful than both groups (77%).

TABLE 8.1. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	16	14	30	53%
LDP	9	13	22	41%
HDP	17	5	22	77%
Total	42	32	74	57%

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

*NP = Non-Participant, LDP = Low-Dose Participant, HDP = High-Dose Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of preexisting GPA, AccuMath score, and SI participation on course success. The null model did not significantly improve after the inclusion of GPA and AccuMath score χ^2 (2) = 4.70, p = 0.11. Additionally, the model did not significantly improve after the inclusion of the SI participant variable, χ^2 (2) = 3.58, p = .33. Low-Dose participation did not significantly predict course success, z (66) = -.72, p = .47; moreover, High-Dose participation did not significantly predict course success, z (66) = 1.30, p = .20.

TABLE 8.2. - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	-356.94 (519.00)	0.00	0.00	-
GPA	0.53 (0.42)	0.76	1.71	4.07
AccuMath	0.18 (0.26)	0.72	1.19	2.02
LDP	-0.43 (0.59)	0.20	0.65	2.07
HDP	0.86 (0.66)	0.66	2.37	9.37

Note. R^2 = .044 (Hosmer-Lemeshow), .10 (Cox-Snell), .24 (Nagelkerke). Model $\chi^2(2) = 3.58$, $p > .05$

MATH150 RESULTS

Descriptive Statistics

In MATH150, there were a total of 380 students who earned a final grade for the fall 2015 semester. The gender breakdown consisted of 183 females (48%) and 191 males (50%); 6 students did not disclose their gender (2%). Two-hundred and three students were non-participants (53%), while 112 students were Low-Dose participants (29%) and 65 were High-Dose participants (17%). Table 9 shows the descriptive statistics for SEMGPA-MATH032 and AccuMath score by participation group.

TABLE 9. SEMGPA & AccuMath Score

	SEMGPA - MATH150					AccuMath Score				
	M	*SD*	*Var*	*Min*	*Max*	*M*	*SD*	*Var*	*Min*	*Max*
NP	2.26	1.22	1.48	0.00	4.00	2004.64	0.87	0.76	2002.00	2008.00
LDP	2.64	1.07	1.14	0.00	4.00	2004.28	1.20	1.43	2002.00	2010.00
HDP	3.12	0.95	0.90	0.00	4.00	2003.85	1.15	1.32	2002.00	2005.00

Success. Success rates were calculated for each SI group. Non-participants had the lowest success rate (58%). Students in the High-Dose group were marginally more successful than the Low-Dose group (72% compared to 69%).

TABLE 9.1. - Success Rates for SI Groups

	Successful	Unsuccessful	Total	Success Rate[a]
NP	117	86	203	58%
LDP	77	35	112	69%
HDP	47	18	65	72%
Total	241	139	380	63%

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 = Low-Dose Participant, HDP = High-Dose Participant

Inferential Test

A hierarchical binomial logistic regression analysis was conducted to evaluate the predictability of SEMGPA-MATH150, AccuMath score, and SI participation on course success. The null model significantly improved after the inclusion of SEMGPA-MATH150 and AccuMath χ^2 (2) = 89.22, p = .0, such that SEMGPA-MATH150 significantly predicts success, z (356) = 8.09, p < .001; AccuMath score did not significantly predict success, z (356) = -.354, p = .723

After the inclusion of the abovementioned variables, the SI participant variable did not significantly improve the model fit, χ^2 (2) = .279, p =.869, such that Low-Dose SI participation does not significantly predict success, z (354) = .527, p = .598; moreover, High-Dose participation did not significantly predict course success, z (354) = .180, p = .857. Alternatively, SEMGPA-MATH150 remained significant and the odds ratio reveals that as students SEMGPA-MATH150 increased by a unit, the change in the odds of success is 2.69: students are more likely to be successful in MATH150 if they earned high marks in other classes during the concurrent semester.

TABLE 9.2. - Results of binomial logistic regression

		95% CI for odds ratio		
	Estimate (SE)	Lower	Odds Ratio	Upper
Constant	67.42 (263.85)	0.00	-	-
SEMGPA-MATH150	0.99 (0.13)***	2.12	2.69	3.49
AccuMath	-0.03 (0.13)	0.75	0.97	1.25
LDP	0.16 (0.29)	0.66	1.17	2.09
HDP	0.07 (0.44)	0.50	1.07	2.39

Note. R^2 = .000596 (Hosmer-Lemeshow), .22 (Cox-Snell), .30 (Nagelkerke). Model $\chi^2(2)$ = .279, p = 0.869, ***p < .001

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 (except for MATH142). Additionally, AccuMath scores significantly predicted success in the two most basic math courses observed in this study (MATH029 and MATH030), suggesting that scores on the Accuplacer may not be a strong representation of a student's math ability, especially in courses above the elementary algebra level. SI group membership was not significantly associated with student success in any analysis.

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 a collegiate GPA variable controls for student ability and motivation, enabling the findings to be interpreted over and above a key variable in academic success. Second, incorporating a standardized math score (the Accuplacer Math test) as a predictor of student success integrates an additional feature of academic aptitude (Grove et al, 2006), asserting that two empirically and theoretically relevant variables were controlled for. 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 student success and SI attendance are not significantly associated to each within the context of GE STEM courses.

APPENDIX

Success and Participation Rates

The participation and success rates indicated in the table below reflect the fall 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	572	497	75	13%	68%	84%
MATH029	150	121	29	19%	61%	86%
MATH030	277	224	53	19%	52%	64%
MATH032	90	69	21	23%	64%	90%
MATH142	74	52	22	30%	48%	77%
MATH150	380	315	65	17%	62%	72%
Total	1,543	497	75	17%	62%	77%

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