Research in Brief

John H. Schuh, ASSOCIATE EDITOR

The Impact of Supplemental Instruction: Results From a Large, Public, Midwestern University

Kari A. Hensen Mack C. Shelley, II

Supplemental Instruction (SI) is an academic support program developed by Deanna Martin, at the University of Missouri at Kansas City in 1973, utilizing peer-assisted study sessions to enhance student performance and retention (Widmar, 1994). The goals of SI include improving students' grades in traditionally difficult courses, reducing the attrition rate in those courses, and helping students develop study strategies to assist them in future courses (Behrman, Dark, & Paul, 1984; Martin, Blanc, & DeBuhr, 1983; Peters, 1990; Prather, 1983; Wolfe, 1987).

The SI model is a unique academic support program targeting difficult courses rather than high-risk students. This voluntary program is not viewed as remedial, as it is open to all students enrolled in the targeted course. A peer student leader, called an SI Leader, is hired and trained to facilitate regularly scheduled study sessions to assist students with course content and study skills. This student attends lecture regularly and plans two 90-minute structured review sessions. The SI Leader does not re-lecture to the students, but rather utilizes collaborative learning strategies to assist students (Martin & Arendale, 1993).

The foundation and theoretical framework for SI is based on student development theory, cognitive development models, learning collaboration methods, and retention research. The major premises of writing on cognitive development (Dale, 1969; Perry, 1968; Piaget, 1950) and student development and retention (Astin, 1987, 1993; Pascarella & Terenzini, 1991; Tinto, 1993; Upcraft & Gardner, 1989) were incorporated in the SI model. Robert Blanc is credited with anchoring SI in a developmental framework (Martin & Arendale, 1993): "The many men and women who form study groups report that they both enjoy their work more, and feel they learn more, because of the academic discussions in these groups" (Light, 1990, p. 18). Astin (1987) found that collaborative approaches to learning "produce better learning in the vast majority of studies; the method is highly cost-effective and helps solve two of our most vexing pedagogical problems: large class size and gross differences in educational preparation" (p. 17).

In 1981 the U.S. Department of Education designated SI an Exemplary Education Program, predicated on the finding that SI is one of two programs that improves student academic achievement and retention. The U.S. Department of Education validated the following claims of effectiveness for the SI program based on research conducted by the Center for Supplemental Instruction at the University of Missouri–Kansas City:

Kari A. Hensen is Supplemental Instruction Coordinator and doctoral student in Educational Leadership and Policy Studies at Iowa State University. Mack C. Shelley, II, is Professor of Statistics and Educational Leadership and Policy Studies at Iowa State University.

1. Students participating in SI within the targeted historically difficult courses earn higher mean final course grades than students who do not participate in SI. This is still true when differences are analyzed, despite ethnicity and prior academic achievement.
2. SI participants withdraw from classes at a lower rate and receive a lower percentage of D or F final grades than those who do not participate in SI.
3. Students participating in SI persist at the institution at higher rates than non-SI participants (Center for SI, 1998, p. 2-3).

Today, over 600 institutions around the world have implemented an SI program to improve students' grades in difficult courses and reduce attrition rates.

CONTEXT FOR THE STUDY

In 1992 Landgrant University (Landgrant U, a pseudonym), a large, public Midwestern institution, established a SI program targeting difficult entry-level mathematics and sciences courses. In addition to being enrolled in large-size classes, a high percentage of students (> 30%) received D and F grades or withdrew from these courses. Today the program has grown from offering SI for a few courses in biology, chemistry, and physics each semester, to having 60 SI Leaders assist students with a wide variety of academic courses each academic year. During the 1999-2000 academic year, SI Leaders spent a total of 10,131 contact hours, assisting 2,909 students with their course work.

Since 1993, data have been collected at

TABLE 1.
SI Participant Data at Landgrant U, 1993-1999

Year	Participants			# Enrolled	# SI Leaders	Final Grade
1993-1994	SI	574	(29%)	1,977	16	2.26
	Non-SI	1,403	(71%)			2.01
Spring 1995 *	SI	248	(22%)	1,122	9	2.27
	Non-SI	874	(78%)			2.16
1995-1996	SI	875	(22%)	3,988	21	2.50
	Non-SI	3,113	(78%)			2.11
1996-1997	SI	1,325	(20%)	6,596	33	2.55
	Non-SI	5,271	(80%)			2.31
1997-1998	SI	1,615	(22%)	7,432	36	2.39
	Non-SI	5,817	(78%)			2.23
1998-1999	SI	2,132	(18%)	11,964	37	2.57
	Non-SI	9,832	(82%)			2.26
1999-2000	SI	2,909	(33%)	8,768	54	2.55
	Non-SI	5,859	(67%)			2.11

* Fall 1994 data not available.

TABLE 2.
SI Course Offerings at Landgrant U, 1999-2000

Department	Course	SI Sec[a]	Enrollment[b]
Biology	Biology 201	7	2,039
	Biology 202	4	
Chemistry	Chemistry 163	3	2,290
	Chemistry 167	2	
	Chemistry 177	2	
	Chemistry 178	1	
	Chemistry 331	2	
Math	Math 142	2	1,483
	Math 150	2	
	Math 151	1	
	Math 165	5	
	Math 166	2	
Physics	Physics 111	2	1,526
	Physics 221	5	
	Physics 222	1	

[a] Sections Offering SI.
[b] Number of Students Enrolled.

Landgrant U for each course offering SI. Table 1 summarizes information reported annually for students' enrolled in courses offering SI from fall 1993 to spring 1999. A SI Participant is defined as a student who has attended at least one SI session. A non-SI Participant is defined as a student who has not attended a SI session.

From 1993-1999 SI participants earned on average higher course grades than students who did not participate in the program. An average of 22% of students enrolled in courses offering SI participated in the program. SI offerings have grown each semester since the program's implementation.

PURPOSE

The purpose of this study was to determine the impact of SI for students in selected entry-level biology, chemistry, mathematics, and physics courses during the 1999-2000 academic year. Courses in these academic areas were selected because they comprise the largest and most consistent courses that have been offering SI since the program's implementation. The following research questions guided the study:

1. Do SI participants in entry-level biology, chemistry, mathematics, and physics courses receive higher mean final course grades than non-SI participants?
2. Is there a relationship between students' preentry characteristics (ACT composite scores) and students' participation in SI?
3. Controlling for students' preentry characteristics (ACT composite scores), do students who attend SI do better than students who do not participate in the program?

Answers to these questions potentially could guide program growth and implementation and provide an enhanced picture of the impact of SI for difficult freshman and sophomore (100-200-level) courses.

METHODOLOGY

A total of 7,339 students were enrolled in entry-level biology, chemistry, mathematics, and physics courses offering SI during the 1999-2000 academic year. Of these students, 58% were male and 42% were female. Human Subjects (Institutional Review Board) clearance and permission from the Registrar's office at Landgrant U to conduct research on the SI program were obtained each semester. Class rosters for each course were obtained from the Registrar's Office

and converted into an Excel database. The rosters obtained in 1999-2000 contained each student's Social Security number, first and last name, year in school, ACT composite score, and course section. During the semester SI participants were requested to sign an attendance sheet to track their participation in the program. These records were compiled in the database throughout the semester. Final course grades were added to the database at the conclusion of the semester.

Finally, the Excel database was converted to a database using the Statistical Package for the Social Sciences (SPSS), to enable advanced statistical analysis. A combined data set for each academic discipline (biology, chemistry, mathematics, and physics) was created to control for grading and instructor bias. Table 2 illustrates the specific courses included in the study and the number of students enrolled in courses offered in each academic discipline.

Final course grades were recoded and combined to create categories that are functional for reporting the data. The grades were grouped into the following categories: (1) A and B grades, (2) C grades, and (3) grades of D and F, and withdrawals. These categories were used to facilitate reporting the results as high grades, average grades, and low grades, respectively. These categories are consistent with national research methodologies implemented by the Center for SI at the University of Missouri–Kansas City.

One-way analysis of variance (ANOVA) was used to determine if SI participants' mean final course grades differed significantly from those of non-SI participants and whether SI participants had higher mean ACT composite scores than non-SI participants. ANOVA is a general linear model procedure used commonly to analyze mean differences between groups. In addition, one-way analysis of covariance (ANCOVA) was used to determine whether, controlling for students' preentry characteristics (ACT scores), students who participate in SI receive higher mean final course grades than do non-SI participants. ANCOVA is a technique used to determine if population means on the dependent variable are the same across all levels of a factor, adjusting for the effects of covariates, which are continuous predictor variables included in the analysis (Green, Salkind, & Akey, 2000).

Chi-square analyses, based on two-way contingency tables, were used to compare the relative frequency of (1) As and Bs, (2) Cs, and (3) Ds, Fs, and withdrawals earned by SI participants and non-SI participants. The chi-square distribution is a nonparametric test used to determine whether there is any association between the distributions of two categorical variables (SI participants and non-SI participants, and the three levels of grade performance) (Hinkle, Wiersma, & Jurs, 1998). An alpha level of 0.05 was used to determine the statistical significance of the chi-square tests. Descriptive summary statistics were developed using two-way contingency table analysis.

Results for Research Question 1

The first research question asked whether SI participants in entry-level biology, chemistry, mathematics, and physics courses receive higher final course grades than do non-SI participants. One-way analysis of variance (ANOVA) was used to determine if the mean final course grades for SI participants differed significantly from the mean for non-SI participants. A 95% confidence level (that is, an alpha level of .05) was used for this test. It should be noted that

TABLE 3.

Academic Achievement at Landgrant U, 1999-2000

Course	SI[a]	Participants		Percent A & B	Percent C	Percent D, F, & W[b]	Final Grade	*SD*
Biology	11	Total	2,039	857 (42.0%)	644 (31.6%)	538 (26.4%)	2.30	1.15
		SI	929	429 (46.2%)**	338 (36.4%)**	162 (17.4%)**	2.43*	1.03
		Non-SI	1,110	428 (38.4%)**	306 (27.6%)**	376 (33.9%)**	2.18*	1.24
Chemistry	10	Total	2,290	882 (38.5%)	751 (32.8%)	657 (28.7%)	2.29	1.05
		SI	761	342 (44.9%)**	274 (36.0%)**	145 (19.1%)**	2.46*	0.91
		Non-SI	1,529	540 (35.3%)**	477 (31.2%)**	512 (33.5%)**	2.21*	1.11
Math	12	Total	1,483	546 (36.8%)	372 (25.1%)	565 (38.1%)	2.16	1.25
		SI	422	182 (43.1%)**	113 (26.8%)**	127 (30.1%)**	2.32*	1.11
		Non-SI	1,061	364 (34.3%)**	259 (24.4%)**	438 (41.3%)**	2.09*	1.29
Physics	8	Total	1,526	500 (32.8%)	394 (25.8%)	632 (41.4%)	2.05	1.23
		SI	267	101 (37.8%)**	97 (36.3%)**	69 (25.8%)**	2.30*	1.03
		Non-SI	1,259	399 (31.7%)**	297 (23.6%)**	563 (44.7%)**	2.00*	1.26

[a] Number of SI Courses.
[b] W = Withdrawal.
* Significant difference of means (*F* test) at $p < 0.05$.
**Chi-square $p < 0.05$.

there is a difference in the numbers of SI participants vs. non-SI participants for each academic subject. Follow-up pairwise comparisons were conducted to evaluate the differences been the categories. Holm's sequential Bonferroni method (Green et al., 2000) was used to control for type I error across the comparisons. Table 3 illustrates the findings for each course.

A two-way contingency table analysis was conducted to provide descriptive statistics illustrating the final grade categories received by SI participants and non-SI participants. Pearson chi-square tests with a 95% confidence level were used to analyze the relationship between the final grade categories and the SI participant/non-SI participant variables.

An analysis of data on final course grades found that SI participants in biology, chemistry, mathematics, and physics courses earned a significantly higher percentage of A and B grades, a significantly lower percentage of Ds, Fs, and withdrawals, and significantly higher mean final course grades than did SI nonparticipants.

Results for Research Question 2

The second research question asked if there is a relationship between students' preentry characteristics (ACT composite score) and participation in SI. It should be noted that ACT composite scores were not available for all students in the sample: 283 scores (14%) were unavailable for students in the biology group, 347 scores (15%) were unavailable for the chemistry group, 209 scores (14%) were unavailable for the mathematics group,

and 234 (15%) were not available for the physics group.

The Office of Institutional Research at Landgrant U reported in its 1999-2000 Student Profile Report that approximately 16.9% of students were international students or from a U.S. state other than where the institution is located. This could account for the number of students who did not take the ACT examination. In future studies SAT scores will be requested in addition to ACT composite scores.

A one-way analysis of variance (ANOVA) was conducted to determine if students with stronger preentry characteristics (higher ACT composite scores) were more likely than those with lower ACT composite scores to participate in SI. The independent variable, SI participation, included two levels: a SI participant is defined as a student attending at least one SI session, and a non-SI participant is defined as a student attending no SI sessions. The ANOVA *F* test evaluated whether the group means on the dependent variable (ACT Composite score) differ significantly from each other. Table 4 illustrates the findings.

The ANOVA *F*-test results demonstrated that SI participants for biology, chemistry, and mathematics had significantly lower ACT composite scores than did the non-SI participants, and hence did not have stronger preentry characteristics before entering the course. The results for the physics students revealed that there was not a significant difference between the mean ACT composite scores for SI and non-SI participants.

Results for Research Question 3

The final research question asked whether, despite possible differences in mean preentry characteristics (ACT composite scores), SI participants earn higher final course grades than do those students who do not participate in SI. Analysis of covariance (ANCOVA) was utilized to determine whether the population mean on the dependent variable, final course grade, adjusted for differences on the covariate (ACT composite score and total number of SI sessions attended), differed across the groups of SI participant and non-SI participant. A 95% level of confidence was used for this analysis.

The findings indicate that after controlling for students' preentry characteristics, SI participants still do better. The results are summarized in Table 5. These results assume the absence of covariate (ACT) by treatment (SI participant vs. non-SI participant) interaction. For biology, mathematics, and physics, a test for interaction effects showed these not to be significant; there were significant conditional effects, however, for chemistry, for reasons that at this time are

TABLE 4.

Mean ACT Composite Scores for SI Participants and Non-SI Participants

Course	Participants	*N*	Mean Act	*SD*
Biology*	Non-SI	959	24.63	4.21
	SI	798	23.99	3.77
	Total	1,757	24.34	4.03
Chemistry*	Non-SI	1,300	25.65	4.12
	SI	643	25.04	3.72
	Total	1,943	25.44	4.00
Math*	Non-SI	914	24.55	3.84
	SI	360	24.03	3.76
	Total	1,274	24.40	3.82
Physics	Non-SI	1,065	25.92	3.92
	SI	227	25.95	3.75
	Total	1,292	25.92	3.89

*Significant difference of means at $p < 0.05$.

TABLE 5.

Mean Final Course Grades of SI Participants and Non-SI Participants Controlling for Students' Preentry Characteristics

Course	Participation	*N*	Adjusted Mean GPA	Unadjusted Mean GPA	*SD*	Variation[a]
Biology*	Non-SI	959	2.19	2.14	1.25	19.0%
	SI	798	2.45	2.49	1.03	
	Total	1,757	2.31	2.32	1.16	
Chemistry*	Non-SI	1,300	2.21	2.18	1.10	16.0%
	SI	643	2.46	2.50	0.92	
	Total	1,943	2.29	2.34	1.05	
Math*	Non-SI	914	2.09	2.08	1.28	8.2%
	SI	360	2.36	2.38	1.08	
	Total	1,274	1.17	2.23	1.23	
Physics*	Non-SI	1,065	2.00	2.00	1.26	12.0%
	SI	227	2.33	2.35	1.04	
	Total	1,292	2.06	2.18	1.22	

[a] Percent Variation Explained by ACT.

*Significant difference of means at $p < 0.05$.

not clear. Adjusted means are reported in Table 5, indicating expected mean final course grade if ACT mean scores were equal between the two (SI and non-SI groups). In general, adjusting for ACT differences between groups does not alter the basic result that SI participants had higher final course grades on average than did non-SI participants.

LIMITATIONS OF THE STUDY

This study has addressed the impact of SI at Landgrant U for the 1999-2000 academic year in entry-level biology, chemistry, mathematics, and physics courses. Additional courses offering SI during the 1999-2000 academic year were omitted from this study. Results of this analysis may not be replicable or generalizable at other institutions, although the findings are consistent with national studies conducted at other institutions. An important limitation of the data analyzed here is that ACT composite scores were not available for a number of the students included in this study. SAT scores will be requested in future studies; the SAT scores may be translated into ACT-equivalent values using tables of correspondence between the two sets of scores, thereby reducing considerably the amount of missing data. In addition, this study does not address the effect of students' motivation to participate in SI.

This study is limited to a large, public, Midwestern university utilizing SI; however, because the program is based on both theory

and practice, and has been used at a variety of institutional types (large, small, public, private, community college, research university), the findings presented here make a strong case for future research enhancements and demonstrate how other institutions may utilize an SI program to meet similar student needs on their campus.

DISCUSSION

The purpose of this study was to determine the impact of SI for Landgrant U students in selected entry-level biology, chemistry, mathematics, and physics courses during the 1999-2000 academic year. composite scores) and students' participation in SI? An analysis of data on final course grades and withdrawal rates found that SI participants earned a significantly higher percentage of A and B grades, earned a significantly lower percentage of Ds, Fs, and withdrawals, and had significantly higher mean final course grades than did non-SI participants in entry-level biology, chemistry, mathematics, and physics courses. This finding was consistent with previous research conducted at Landgrant U and in other SI programs across the country. Table 6 provides a comparison of the percentage of As and Bs, and of Ds, Fs, and withdrawals, earned at Landgrant U, com-

TABLE 6.

Comparison of Landgrant U and National SI Data

Course	# SI Courses	Participation	Percent A & B	Percent D, F, & W[a]	Final Grade
Biology–Landgrant U	11	SI	46.2%	17.4%	2.43
		Non-SI	38.4%	33.9%	2.18
Biology–National	528	SI	45.5%	21.8%	2.39
		Non-SI	35.2%	33.5%	2.12
Chemistry–Landgrant U	10	SI	44.9%	19.1%	2.46
		Non-SI	35.3%	33.5%	2.21
Chemistry–National	718	SI	46.2%	36.9%	2.40
		Non-SI	23.2%	36.9%	2.08
Mathematics–Landgrant U	12	SI	43.1%	30.1%	2.32
		Non-SI	34.3%	41.3%	2.09
Mathematics–National	30	SI	45.6%	30.4%	2.32
		Non-SI	31.5%	48.4%	1.88
Physics–Landgrant U	8	SI	37.8%	25.8%	2.30
		Non-SI	31.7%	44.7%	2.00
Physics–National	129	SI	45.1%	24.4%	2.42
		Non-SI	35.9%	36.9%	2.14

[a] W = Withdrawal.

pared to National SI Field Data collected by the Center for Supplemental Instruction at the University of Missouri–Kansas City from 270 institutions between 1982-1996 (Center for SI, 1998, p. 22-25). Landgrant U data were not included in this national study.

Table 6 shows that Landgrant U SI participants earn higher mean final course grades in biology and chemistry compared to the national SI average for these courses. Landgrant U SI participants earn the same mean final course grades for math and earn lower mean final course grades in physics. In biology, chemistry, and mathematics courses, Landgrant U SI participants earn a smaller proportion of D, F, and withdrawal grades than the national SI average. In physics, Landgrant U students earn a larger proportion of D, F, and withdrawal grades than the national average.

This study also found that SI participants have lower preentry characteristics (ACT composite scores) than non-SI participants, contradicting the belief of many that participants' higher mean final course grades can be attributed to higher-achieving students participating in the program. Despite having lower ACT composite scores, SI participants in biology, chemistry, and mathematics courses achieved higher final course grades than did those who did not participate in SI. These findings reject the notion that only students with high ACT scores participate in SI. It appears that students of all levels are utilizing the program and being impacted by that participation. Finally, this study has concluded that even after controlling for students' preentry characteristics and adjusting for how many sessions SI participants attend, SI participants still receive significantly higher final mean course grades than non-SI participants.

Implications for Student Affairs

SI is an academic support program that truly bridges student affairs and academic affairs work. With the increasing diversity of today's college students, SI plays an increasingly central role as a program designed to ensure that all students have a support mechanism to help them succeed in traditionally difficult foundation courses. SI has proven to be a successful academic support model for "both males and females from all ranges of previous academic achievement and ethnicity" and has also been effective with a variety of disciplines at all institutional levels and types (Martin & Arendale, 1993). Student affairs professionals looking for a "new" retention initiative may find SI to be an economical and effective approach to ensure that students are successful during the most crucial phases of their college development.

Future Research

SI is an academic support program at Landgrant U that helps students perform significantly better in difficult entry-level biology, chemistry, mathematics, and physics courses. Additional research is needed to analyze the impact of the SI program further. Future studies should examine the differential impact of SI on minority and first-generation college students, on learning community participants, and on students in different academic disciplines. Another unanswered question is what motivates students to participate in a voluntary study session program. Examining students' motivation for participating in SI will help to guide program development and implementation, and ultimately may increase both the breadth and depth of student participation in SI. This will be accomplished at Landgrant U through a short survey administered

at the beginning of each semester. Further examination into the sources of interaction effects in certain disciplines, such as chemistry in this case, should yield insights into how to tailor SI to meet the needs of all students. Future studies also should examine the impact on student performance of the number of SI sessions attended; tentatively, our results show that the more SI sessions students attend, the better their performance.

Correspondence concerning this article should be addressed to Kari A. Hensen, 1076 Student Services Building, Iowa State University, Ames, IA 50011-2222; khensen@iastate.edu

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