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Supplemental Instruction and the Performance of Developmental Education Students in an Introductory Biology Course

Although first-year students in Supplemental Instruction (SI) earned similar average numerical-grades in an introductory biology course as non-SI students, their grade distributions were different: SI students earned fewer Ds and Fs than non-SI students. SI students who earned As and Bs had similar admissions scores as those who earned D's and F's, but were distinguished by their academic behaviors: they submitted more extra-credit work and came to more classes, help sessions, and office hours than non-SI students. These data indicate that SI can help at-risk students in an introductory biology course to engage in positive academic behaviors and to improve their academic performance.

Many colleges and universities are increasingly concerned about enrolling, retaining, and graduating a diverse population of students. To accomplish this goal, colleges and universities are enrolling larger percentages of traditionally under-represented groups. However, because many of these students are academically at-risk, colleges have implemented a variety of support services to help ensure the academic success of these students. These services are especially important in introductory science courses, as these courses are often characterized by higher failure rates than other courses (Congos, Langsam, & Schoeps, 1997).

One of the most effective models of academic support is Supplemental Instruction (SI). SI avoids the stigma of remediation by identifying high-risk courses rather than high-risk students (Arendale, 1994; Ramirez, 1997). Whereas many other support services focus on students' deficiencies, SI focuses on the inherent difficulty of some courses, especially those in which at least one-third of the course-grades are D, F, or W (Ramirez, 1997). SI begins the first week of classes (i.e., well before students take their first exams and are "in trouble") and is voluntary, proactive, attached directly to high-risk courses, taught by leaders who attend all class sessions, and open to all students (Arendale, 1994). At the University of Minnesota where our study was done, SI is a modified recitation that emphasizes effective study skills, collaborative work, and a review of course-content. Additional information about the SI model is presented elsewhere (Arendale, 1994).

Introductory science courses are often high-risk courses because up to half of students at many colleges and universities earn a D, F, or W in these courses (Congos et al., 1997). This is not surprising, because more than three-fourths of students, and especially those in underrepresented groups who took the ACT in 2004 were not prepared for college-level biology (Cavanagh, 2004). Moreover, many students in these courses have had negative experiences in science courses and question their abilities to do well in science courses (Congos et al., 1997). Although some studies have reported that SI students earn higher grades than non-SI students in some science courses (Campbell, 1994; Gaddis, 1994; Peled & Kim, 1996; Shaya, Petty, & Petty, 1993), others have reported no effect of SI in science courses (Collins, 1982; Fest, 2000; Hensen & Shelley, 2003).

In this study we report the findings of a two-year study of the impact of SI in a large introductory biology course. To measure the effectiveness of SI in the course, we compared the academic performances and behaviors of SI and non-SI students, as well as the performances and behaviors of successful and unsuccessful SI students. We wanted to answer several questions: (a) Is SI effective in an introductory biology course? (b) What behaviors are associated with the academic success of SI students? (c) What traits characterize unsuccessful SI students?

Methods

Context of the Study

This study was conducted for four semesters in several large sections of a four-credit introductory biology course for first-year developmental education students in General College (GC) at the Twin Cities campus of the University of Minnesota. GC provides access to the university for students from diverse cultural, educational, and socio-economic backgrounds who do not meet all of the admissions requirements of the university's other colleges. GC prepares students to transfer to one of the university's degree-granting colleges. Students in GC are considered to be "at risk" because they have lower grades, ACT scores, and high school graduation percentiles than most other students at the university. Courses in GC are content-rich, credit-bearing, transferable courses that count fully toward graduation from the university. Additional information about GC, its mission, its focus on advising, and its students can be found elsewhere (Higbee, Lundell, & Arendale, 2005).

The introductory biology course in this study covered topics typical of a traditional introductory biology course for non-majors. Lectures occurred twice per week for 75 minutes per class. All sections of the course met near the same time of day and were taught by the same instructor in the same classroom in the same way (e.g., the same syllabus, textbook, sequence of topics, grading policy, exams, and pedagogical techniques). The course syllabus included the following statement about the importance of attendance for academic success: "I expect you to prepare for and attend every class. This is important because class attendance is usually a strong indicator of course performance." The instructors also discussed these statements and the importance of class attendance on the first day of class in both sections. The biology course enrolled an average of 35 SI students and 310 non-SI students per semester. All students (i.e., SI as well as non-SI) were in the same class, took the same exams, attended the same labs, and had the same grading criteria. Both the lecture and laboratory portions of the course were integrated into students' final grades. Additional information about this course is presented elsewhere (Moore, 2003a, 2003b).

SI classes met three times per week for 50 minutes per class and were led by a SI leader who had an undergraduate degree in biology, attended every class, and did all of the course assignments. The SI leader had no access to or input regarding exams or course grades; that is, SI students did not receive any "inside information" about exams at SI sessions.

Participants

On average, 37 SI-students and 361 non-SI students participated in the study each semester. Approximately 55% of the SI students were male, and 45% were female. The students were ethnically diverse: 25% African American, 9% Asian Pacific, 6% American Indian, 50% Caucasian, 5% Chicano, 3% Hispanic, and 2% Other. For comparison, non-SI students were approximately equal percentages of men and women and were also ethnically diverse: 20% African American, 2% American Indian, 20% Asian American, 51% Caucasian, 4% Chicano/Latino, and 3% undeclared (University of Minnesota, General College, 2003). All students in the SI course were enrolled in the course from the first day; none were added late. Students who officially dropped the course (for whatever reason) were not included in this study.

What We Measured

We used institutional records to obtain students' ACT Aptitude Ratings (AAR), which is the student's ACT composite score plus two-times their high-school graduation percentile. We used a survey on the first day of classes to determine (a) whether students had taken a biology course in high school, (b) whether students believed they would do extra-credit assignments if given the opportunity to do so, and (c) the percentage of classes the students planned to attend.

We recorded the following academic performances and behaviors of all SI and non-SI students in the course:

1. Grades. We tracked the grades of SI students and non-SI students on lecture exams, a comprehensive final, and in lab. Grades represented students' mastery of course material and skills. Although students who attend and engage themselves almost always earn above a C, students received no academic credit for class attendance or class participation (Moore, 2003a, 2003b).

2. Attendance at lectures. We measured class attendance every day with short in-class writing assignments. Students were told that class attendance is associated with academic success, but students received no points for attending class.

3. Attendance at optional help-sessions. These data were recorded by teaching assistants who led help sessions. Help sessions were held before each exam and were conducted by teaching assistants who had no knowledge of, or input regarding, any of the exams. Attendance was optional; no points were given for attending the help sessions, and students who attended received no points or "inside information" about upcoming exams.

4. Visits during office hours. We kept records of students who talked with the instructor about content-related information during office hours and before or after class. Students received no points for coming to office hours or for asking questions before, during, or after class.

5. Submission of extra-credit work. Opportunities to earn extra-credit (one-third of the points that they had missed on the lecture exams) required that students write a one-page answer for each of the questions

that they missed on an exam. Students had four weeks to write and submit these essays. The extra-credit points were guaranteed for any reasonable effort. Points earned by students who submitted extra-credit work were excluded from all calculations and data in this study.

Table 1
Academic Performances and Behaviors of SI and Non-SI Students

	SI	Non-SI
Academic Behaviors		
% Attendance at lectures	73	71
Number of office hour visits per student	0.1	0.1
% Students who did extra credit work	14	16
% Students who attended help session	28	24
Academic Performance		
Lecture exams	67	64
Laboratory	74	72
Final exam	67	68
Course grade	70	68
Final Course Grade Distribution		
A	4	13
B	29	26
C	46	28
D	8	13
F	11	20

Table 2
Academic behaviors and performances of SI students who earned an A or B compared with those who earned a D or F.

	A or B	D or F
Academic Behaviors		
Attendance at lectures, %	93	52
Visits to office hours per student per semester	0.2	0
% Students who did extra credit work	27	0
% Students who attended help session	53	4
Academic Performance		
Lecture exams	78	59
Laboratory	84	58
Final exam	79	49

Results

AAR. The AAR scores of SI students averaged 83, whereas those of non-SI students averaged 93. These average scores were significantly different ($p < 0.01$, independent t-test). However, the AAR scores of SI students who earned As and Bs (84) were not significantly different from those of SI students who earned Ds and Fs (83; $p < 0.05$)

Pre-college exposure to biology. The first-day-of-classes survey indicated that 97% of SI students, and 98% of non-SI students, had taken a biology course in high school. These averages were not significantly different. Similarly, 96% of SI students who earned As and Bs, and 97% of SI students who earned Ds and Fs, had taken a biology course in high school. These averages were not significantly different ($p > 0.05$).

Students' expectations on the first day of classes. On the survey, 82% of SI students, and 85% of non-SI students, claimed that they would submit extra-credit work if given the opportunity to do so. These averages were not significantly different. SI students claimed that they would attend an average of 92% of class and earn an average final grade of 88%, and non-SI students claimed that they would attend an average of 91% of classes and earn an average grade of 90%. These averages were not significantly different ($p > 0.05$).

Academic performances and behaviors. Our research questions are addressed by data in Table 1, which summarizes the academic performances and behaviors of SI and non-SI students. Similar patterns occurred in every section during every semester of every year of this study. SI students and non-SI students earned similar average numerical grades in all aspects of the course (i.e., lecture exams, laboratory, final exam, and course grade). These similarities in academic performances were associated with similar academic behaviors of SI-students and non-SI students (Table 1). The academic behaviors and performances of SI students and non-SI students summarized in Table 1 were not significantly different.

Although data in Table 1 revealed no significant differences in the average academic performances and behaviors of SI and non-SI students ($p > 0.05$), these data included some SI students who disengaged from the course (e.g., students who quit coming to class regularly, seldom submitted assignments, and missed SI sessions). We suspected that these students' poor performances could mask important conclusions about what behaviors characterize successful and unsuccessful SI students. To examine this, we compared the academic behaviors of SI students who earned As and Bs in the course with those of SI students who earned Ds and Fs. These comparisons are shown in Table 2. Similar patterns occurred every semester of every year of this study. Successful and unsuccessful SI students had similar pre-college admission scores (i.e., AAR), pre-college exposure to biology, and first-day-of-classes expectations, but their academic behaviors were significantly different: successful SI students submitted more extra-credit work and attended more lectures, office hours, and help sessions than unsuccessful SI students (Table 2). All of the differences in Table 2 were significantly different ($p < 0.01$).

Discussion and Conclusions

Some earlier studies of the effectiveness of SI have been vulnerable to a self-selection bias that has lowered the validity of the data; that is, the SI courses in some studies have enrolled only the most motivated and academically well-prepared students (Congos et al., 1997). That bias was not present in this sample. Although SI was voluntary and open to any student, the students who enrolled in SI had AAR scores that were significantly lower than those of their non-SI classmates (83 vs. 93, respectively, for SI and non-SI students). Although some studies have suggested that AAR scores are poor predictors of the academic success of developmental education students (Moore, 2003a, 2003b, and studies cited therein), these studies have not focused on SI students, and therefore may not be applicable to the SI students studied here. Nevertheless, if SI students' relatively low AAR scores did, in fact, make them academically less prepared for college than their non-SI classmates, then the SI students' participation in the SI program improved the students' grades. Indeed, on average, SI students did as well in this historically difficult course as non-SI students (Table 1). Regardless, these data support Ramirez (1997), that scores on standardized tests are poor predictors of the academic success of SI students.

Although SI and non-SI students ended the course with similar final numerical grades, their grade distributions were consistently different. Indeed, SI students made more Cs, similar percentages of Bs, and smaller percentages of As, Ds, and Fs than non-SI students. Our finding that SI students were less likely to make a D or F in the course than non-SI students is similar to that reported in other studies (Congos et al., 1997; Congos & Schoeps, 1998; Hensen & Shelley, 2003) and suggests that participation in SI may be especially helpful to students who would have otherwise earned a D or F in the course.

Data presented in Table 1 were presumably not influenced by differences in pre-college exposure to biology, for virtually identical percentages of SI and non-SI students had taken a biology course in high school (97% vs. 98%, respectively). The same was true for SI students who earned As and Bs as compared to those who earned Ds and Fs. These results indicate that the different academic performances reported here for SI and non-SI students (as well as for successful and unsuccessful SI students; see below) were not due to differing degrees of pre-college exposure to biology.

On average, SI and non-SI students had high expectations on the first day of class; they expected to attend 90% of classes, earn a high grade in the course, do extra-credit work, and earn either an A or B in the course. However, most students' behaviors (i.e., those of SI and non-SI students alike) did not match their predictions, for the students attended an average of only 70% of classes, and only 16% submitted extra-credit work. Students having these lower-than-predicted rates of attendance and course engagement also earned lower-than-predicted average course grade of 70 (i.e., a C-). These results support the claims that (a) developmental education students (SI and non-SI alike) often ignore course-related opportunities and have behaviors and attitudes that are inconsistent with academic success (Grisé & Kenney, 2003; Yaworski, Weber, & Ibrahim, 2000), and (b) SI students, like other developmental education students, often have high expectations but do not follow through on their academic intentions (Pintrich & Garcia, 1994).

There were no differences in the average academic performances of SI and non-SI students in any aspect of the course (Table 1). These similarities in academic performance corresponded to comparable similarities in academic behaviors. Indeed, SI and non-SI students had similar grades and similar rates of submitting extra-credit work and attendance at lectures, office hours, and help sessions. These results are consistent with the claim that motivation-related behaviors (e.g., class attendance), and not scores on standardized pre-college tests, are the most reliable predictor of the academic success of developmental education students (Moore, 2003a, 2003b; Thomas & Higbee, 2000).

Comparing Successful and Unsuccessful SI Students

Successful (i.e., A and B) and unsuccessful (i.e., C and D) SI students had similar AAR scores and pre-college exposure to biology in high school. Therefore, the dramatically different performances of these two groups of students were not due to the pre-college factors that we examined (i.e., AAR and pre-college biology courses). Similarly, both groups of SI students were highly confident of their ability to succeed in the course and exhibited academic behaviors that would help them succeed (e.g., attend class regularly and do extra-credit work). In light of these similarities, what accounts for the different performances of the two groups of students? That is, what factors predict the academic success of SI students?

The differing academic performances of successful and unsuccessful SI students were associated with differences in the students' academic behaviors. Indeed, successful SI students submitted more extra-credit work and attended more lectures, office hours, and optional help-sessions than did unsuccessful SI students. These differences in motivation-related behaviors, and not those in pre-college criteria, described the academic success of SI students. This is consistent with previous studies of other groups of developmental education students in which high rates of attendance and course engagement, and not students' scores on admission tests, most accurately predicted these students' academic success (Moore, 2003a, 2003b; Thomas & Higbee, 2000).

This study had several limitations. For example, although we obtained similar results in a biology class every semester for two years, our conclusions may not be transferable to other science classes. Moreover, correlation is not causality, and our sample-size was relatively small (i.e., only about 35 students per semester). Nevertheless, our results clearly indicate that SI students earned fewer Ds and Fs than non-SI students in an introductory biology course. The most successful SI students were distinguished by their academic behaviors: they submitted more extra-credit work and came to more classes, help sessions, and office hours than non-SI students. Clearly, SI can help at-risk students succeed in science classes, but this success requires effort and academic motivation.

Implications for Retaining Underprepared Students in College Science Courses

1. The results of this study suggest that colleges and universities wanting to improve the academic performance and retention of students in science classes should consider implementing SI programs. Our program helped most underprepared students produce academic records that equaled those of other students. Although SI may be most beneficial to at-risk students (Ramirez, 1997), SI can help all students succeed, not just those in academic trouble (Chandler, 1994).

2. Rampant absenteeism often begins in high school (Fallis & Opotow, 2003) and continues in college (Friedman, Rodriguez, & McComb, 2001; McGuire, 2003; Romer 1993). Not surprisingly, these behaviors are associated with low grades (Moore, 2003a, 2003b). As Romer (1993) has noted, "A generation ago, both in principle and in practice, attendance at class was not optional. Today, often in principle and almost always in practice, it is" (p. 174). To help remedy this problem, instructors, advisors, and other learning assistance professionals should consider using data to show developmental education students (SI and otherwise) that

their academic success in college will require particular behaviors and hard work. Students who attend and engage themselves in courses can succeed, despite their previous histories of academic problems. However, students who will not attend and engage themselves in their courses will probably fail, even if they enroll in SI. Just as merely buying the course textbook does not ensure high grades, merely enrolling in SI also does not ensure academic success. To be successful, programs such as SI require that students try to succeed.

3. Tell students that many of them will not follow through on their first-day-of-classes optimism about academic behaviors such as class attendance and course engagement. Although students who do not follow through on these behaviors will probably fail, the students who do follow through will probably do well. Students have much control over their academic future. Hard work and high levels of academic motivation can help underprepared students succeed in historically difficult courses, thereby enabling them to shed their at-risk label.

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