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About the *Supplemental Instruction Journal*

Supplemental Instruction Journal (SIJ) seeks to publish the latest research in the field and to be the foremost resource for advancements and discoveries related to Supplemental Instruction. SIJ submissions are peer reviewed by national and international education professionals who work with or have worked in some capacity with Supplemental Instruction programs. SIJ is intended for a wide audience.

This issue marks the second publication of the Supplemental Instruction Journal. While the first issue, published in November 2014, included refereed papers from our 2014 International Conference on Supplemental Instruction, this issue is comprised of articles submitted, evaluated, and accepted for publication by SIJ's Peer Review Board.

The articles in this issue explore the benefits of being an SI Leader; the impact of both traditional and online SI in health sciences and STEM fields; and the application of SI as a test-preparation model to improve outcomes for underrepresented students applying to professional school. We at the International Center for SI hope that these articles will broaden readers' understanding of the benefits of SI programs and offer ideas for broadening SI's application to affect change in new arenas.

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The Impact of Online Supplemental Instruction on Academic Performance and Persistence in Undergraduate STEM Courses

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Abstract

Though demonstrated as an effective strategy for enhancing academic performance and course persistence in higher education, traditional Supplemental Instruction (SI) relies on face-to-face interaction in a classroom setting. Consequently, students who have other obligations or feel apprehensive in a group setting often cannot attend traditional SI sessions. This paper focuses on an innovative alternative to traditional SI: an online SI program currently being implemented at Texas A&M University-Corpus Christi (TAMUCC). This paper describes TAMUCC's online SI program and discusses results from a pilot study that compared the STEM course performance and persistence of TAMUCC undergraduates (N=585) randomly assigned to SI

groups (i.e., traditional SI or online SI) in the spring semester of 2015.

Keywords: Supplemental Instruction, Supplementary Education, STEM Education, Higher Education, Online Learning

Impact of Online Supplemental Instruction on Academic Performance and Persistence in Undergraduate STEM Courses

Due an increased emphasis on course persistence and institutional retention in higher education, and especially in STEM departments, many institutions are experimenting with ways to increase positive student outcomes through academic support programs. Among these programs, Supplemental Instruction (SI) continues to be one of the most popular. First developed at the University of Missouri-Kansas City in 1973, SI is a collaborative, peer-assisted model of academic assistance that employs regularly scheduled, out-of-class study sessions (Arendale, 1993). SI is non-remedial, targeting traditionally difficult courses with high rates of student attrition and/or failure rather than individual students. It is free and open to all students in these traditionally difficult classes but is not mandatory. SI sessions give students an opportunity to discuss course material and learning strategies and are facilitated by an SI Leader, a student who has previously taken and excelled in the course. The point of SI is not to re-teach or introduce new material. Instead, the overall goal is to combine *what* students need to learn with *how* they can most effectively learn it in an open, comfortable environment.

The evidence supporting the effectiveness of traditional SI, which occurs face-to-face and in-person, is considerable (Bowles, McCoy, & Bates, 2008; Dawson, van der Meer, Skalicky, & Cowley, 2014; Malm, Bryngfors, & Marner, 2012; Price, Lumpkin , & Seemann, 2012; Rath, Peterfreund, Bayliss, Runquist, & Simonis, 2011). However, in spite of SI's popularity and effectiveness, it does not always fit the needs of all students. For example, nontraditional students, whose enrollment numbers at institutions of higher education have been growing steadily [1] over the past four decades , often have financial, family, and other obligations that make it difficult for them attend face-to-face SI sessions held in campus classrooms during customary daytime instructional hours. Other students struggle in traditional SI sessions because they feel socially inhibited or

[1] In the fall of 1970, 27.8% of persons enrolled in degree-granting postsecondary institutions were at least 25 years old. By the fall of 2012, persons age 25 and older represented 40.5% of enrolled students at such institutions (U.S. Department of Education, 2014).

unable to keep pace with the Leader. However, traditional SI's limitations are not restricted to the challenges it presents to students, as the implementation of traditional SI often forces institutions to overcome significant logistical problems such as where and when to hold sessions when available classroom space is in short supply.

To address the aforementioned challenges, TAMUCC began exploring alternatives to traditional SI and ultimately decided to investigate the feasibility and efficacy of utilizing online SI with STEM courses that have been historically difficult (meaning that typically 30% or more of enrolled students earn a grade of D or F or withdraw prior to the end of the semester) for the institution's undergraduates. To fund this investigation, TAMUCC applied for and was awarded, in October 2014, a *First in the World* (FITW)[2] grant (P116F140206) from the U.S. Department of Education.

Online SI is essentially the same as traditional SI, except that SI Leaders and participants interact through a personal computer or other hardware device instead of in a face-to-face environment (Boggs, Heaney, Kramer, & Williams, 2011). SI Leaders ask questions and share content such as study guides, exercises, videos, PowerPoint presentations, and other documents on the virtual whiteboard. SI Leaders and participants communicate with one another by using a microphone and headset or by typing, which allows participants to receive feedback and communicate with the SI Leader without being constrained to a particular location. Moreover, because online SI sessions are recorded, students can view them anytime and as many times as they wish.

Although a relatively recent phenomenon and not nearly as well studied as traditional SI, online SI models have been shown to have certain advantages over traditional sessions. Painter, Bailey, Gilbert, and Prior (2006) note that online SI allows students access to supplemental materials anytime, anywhere. Students who are anxious about speaking or solving problems in front of others may find online SI appealing because they are not surrounded by other students. The online format allows for easy distribution of additional

[2] FITW (CFDA#84.116F) is " designed to support the development, replication and dissemination of innovative solutions and evidence for what works in addressing persistent and widespread challenges in postsecondary education for students who are at risk for not persisting in and completing postsecondary programs, including, but not limited to, adult learners, working students, part-time students, students from low-income backgrounds, students of color, students with disabilities, and first-generation students" (U.S. Department of Education, 2015).

resources, as well as quizzes and surveys that provide immediate feedback to students. Online SI sessions can be recorded and viewed multiple times for students who missed a session or need additional support. Hurley, Patterson, and Wilcox (2006) argue that this "time to think" facilitates the deepest level of learning and helps students "formulate questions like those modeled by their facilitator, make observations, and consider solutions."

Still, online SI is not without its disadvantages (Painter et al., 2006). The cost of software and related equipment, as well as technical support, often makes online SI prohibitively expensive for some support programs. Similarly, some software companies set limits on the number of users at one time and therefore the number of students that can be served, making their online portals inadequate for conducting SI sessions. Moreover, even when the hardware, software, and technical support are suitable, students sometimes lack the requisite computer-literacy skills or technology (e.g., microphones and cameras) to fully engage in online SI sessions. Finally, in the online environment, SI Leaders may encounter difficulties managing students that would not occur in a traditional SI setting. For example, maintaining student attention can be challenging due to the students' ability to easily leave and reenter the discussion. In addition, SI Leaders may encounter communication issues with subjects such as math and chemistry because these disciplines utilize unique symbols that can be difficult to use in a digital format.

Although ascertaining the effectiveness of online SI has not received the same level of scholarly attention as its traditional SI counterpart, there is some evidence suggesting that participation in online SI positively impacts students' academic achievement and persistence.

Sargent, Borthick, and Lederberg (2013) studied the effect of video-recorded supplementary tutorials on student performance in an introductory accounting course. These tutorials were similar to an SI presentation in that core concepts were explained and applied to individual problems, strategies and processes for problem solving were delineated, and students were encouraged to solve problems for themselves. Each tutorial contained informal comments from the facilitator underscoring common mistakes and misperceptions. These tutorials were then loaded onto a WebCT platform. The resulting pass rate for low-achieving students who accessed the tutorials was significantly higher than the pass rate of the control group, and the tutorial users' exam scores were increased by a half a letter grade. Sargent et al. (2013) also found that tutorial users reenrolled in subsequent semesters at a significantly higher rate than did non-users. Similarly, data from an online SI program at the University of Wyoming found that student use of online SI corresponded to improved course performance compared to those who did not participate in any SI sessions (Boggs et al., 2011). Finally, Ndahi, Charturvedi, Akan, and Pickering (2007) found that a web-based, interactive SI model led to an average gain of 14.05% on exam scores in an introductory engineering class.

Student perceptions of online SI have also been generally positive. Schaffer and Schwebach (2015) studied the use of Livescribe pencasts, which are interactive versions of notes and audio, as supplementary instruction tools for undergraduate students studying cell biology. Students reported that the pencasts helped them learn and retain the material, irrespective of their prior academic performance levels. Use of the pencasts increased dramatically before exams, suggesting that students viewed it as an important study tool. Freeman and Field (2004) found that more than 90% of industrial technology students in an occupational safety course at Iowa State University indicated that online notes and quizzes provided through a WebCT platform helped them prepare better for class. Likewise, 89% of students indicated that the WebCT component improved their learning experience, and 92% said that they were satisfied with the WebCT experience. Ninety-six percent indicated that they preferred to have a class with the WebCT component.

The focus of the pilot study that TAMUCC conducted from January to May 2015 was a randomized control trial to compare the relative effectiveness of online SI with that of traditional SL The goal of the study was to collect evidence that might be useful in ascertaining whether online SI might be a viable alternative to traditional SI for colleges and universities that wish to enhance the STEM course performance and persistence of their students despite experiencing severe resource (e.g., available classrooms) constraints. Thus, the study focused on the following research question: do students assigned to online SI perform as well or better than students assigned to traditional SI in terms of their persistence and grade earned in the STEM course with which the SI is associated?

Method

Participants

In late January 2015, 644 students in select sections of four STEM courses (Biology 2421, Chemistry 1412, Engineering 2322, and Mathematics 1442) were randomly assigned to either online SI (the treatment group) or traditional SI (the comparison group), with an equal number of students within each course section randomly assigned to one group or the other.

From this initial sample, 17 students were removed because they were enrolled in more than one of the four aforementioned STEM courses, 10 students were removed because they dropped their SI-associated course prior to the first day of instruction, and 32 students were removed because they opted-out of the SI group to which they were assigned. However, as shown in Table 1, these removals did not appear to diminish the baseline equivalence of the two groups to any significant degree, as an independent samples, two-tailed, *t*-test of the analytic sample ($N=585$) revealed no statistically or practically significant difference, $t(583)=0.10$, $p=0.92$, $g=0.00$, between the pre-intervention cumulative GPA of the treatment group ($n_1=277$, $M_1=2.82$, $SD_1=0.63$) and the comparison group ($n_c=308$, $M_c=2.82$, $SD_c=0.58$). Moreover, as shown in Table 2, the groups remained equivalent in terms of socioeconomic status, as there was not any statistically or practically significant difference in the Pell-grant-eligibility status of the groups, $\chi^2(1)=0.66$, $p=0.42$, $V=0.03$, with 41.2% of the treatment group and 44.5% of the comparison group being Pell-eligible.

In terms of demographic characteristics, 52.0% of analytic sample members were Hispanic; 62.9% were female; and 42.9% were low-income individuals (as indicated by Pell-grant eligibility). The results of baseline-equivalence analyses for select subgroups in the sample are shown in Tables 1 and 2.

Materials

Members of the treatment group (online SI) and comparison group (traditional SI) were provided the same materials throughout the Spring 2015 semester. The only difference between the SI sessions was the medium through which the two groups received the materials and interacted with their SI Leaders. Members of the comparison group attended SI sessions in a traditional classroom on prescheduled days at prescheduled times, occupied the same physical space as their SI Leaders and other session attendees, and received hardcopy versions of all materials. Members of the treatment group also attended SI sessions on prescheduled days at prescheduled times, but they did so through an online platform called WebEx video conferencing, occupying a completely separate physical space from their SI Leaders and other session attendees and receiving electronic versions of all materials. Moreover, online SI sessions were recorded and then available to treatment group members who either could not attend at the time of broadcast or who wished to watch the sessions multiple times.

WebEx video conferencing permits users to view multiple video feeds at once or side-by-side with a screen sharing mode. During online sessions, SI Leaders can easily redirect questions , facilitate discussions , share content, administer quizzes, and track attendance, just as they would in traditional SI sessions. Users can share content from their own device, collectively annotate documents, and share ideas on a virtual whiteboard from any device with an internet connection. TAMUCC' s use of this platform ensured that the treatment group's SI experience closely resembled that of the comparison group while also permitting the treatment group to capitalize on online SI' s inherent advantages: the ability to receive instruction irrespective of location and view recorded sessions anywhere at any time.

Design and Procedure

After students were randomly assigned to either the treatment or comparison group in January 2015, an equal number of online SI and traditional SI sessions were then conducted weekly (repeated three times on different days at different times) through the end of the semester in May 2015. Students in the analytic sample had the option of attending as many or as few SI sessions as desired within their group category (i.e., online SI or traditional SI).

SI Leaders were TAMUCC students who had already completed and earned a high grade (B or higher) in the course with which their SI sessions were associated. The same SI Leader led both an online SI group and a corresponding traditional SI group for each STEM course s/he was assigned. (For example, if SI Leader #1 led an online SI group associated with Dr. X's Mathematics 1442 class, SI Leader #1 would also lead a traditional SI group associated with that class.) SI Leaders always attended each meeting of the course with which their SI was associated and then, in accordance with guidelines established by TAMUCC' s SI program manager developed lessons to be delivered in the corresponding SI sessions.

Results

The principal goal of this pilot study was to investigate the extent to which online SI might be a viable alternative to traditional SL Consequently, the research questions for the study focus on ascertaining whether students in online SI perform at least as well as those in traditional SI in the outcome domains of credit accumulation (operationally defined herein as persisting in the SI-associated course until the end of the semester) and academic achievement (operationally defined herein as grade earned for the semester in the SI-associated course).

Course Persistence

As shown in Table 3, there was no statistically significant difference between the complete analytic sample's treatment (n_1=277) and comparison (n_C=308) groups in terms of the rates at which they persisted (92% for the treatment group vs. 90% for the comparison group) in their STEM courses to the end of the semester, x2(1)=0.58, p=0.45, *V=0.03*. Moreover, as shown in Tables 4 and 5, there were no statistically significant differences (i.e., all *p>0.05)* between the treatment and comparison groups when just data from the females only, males only, Hispanics only, and Mathematics (MAT) 1442 students only[3] subsamples were analyzed.

Semester Grade Earned

As shown in Table 6, an independent samples, two-tailed t-test revealed no statistically significant difference, t(583)=0.36, *p=0.72*, g=-0.02, between the treatment (n_1=277, M;=l. 88, SD_1=1.28) and comparison (n_C=308, M_C=l. 91, SD_C=l. 25) groups in the complete analytic sample in terms of semester grade earned[4] in the STEM courses with which the SI was associated. Additionally, as shown in Tables 7 and 8, no statistically significant differences between the treatment and comparison groups were found among the females only,

3 Subgroup analysis by course was limited to MAT 1442 students because only this course group (N=384) included enough members to achieve the statistical power necessary to detect small to medium effects.

4 Semester grades earned were coded as follows: A=4, 8 =3, C=2, D= l , F=O, and W=O.

males only, Hispanics only, and MAT 1442 students only subsamples.

Discussion

The results of this pilot study are very promising, as the online SI group appeared to perform as well as the traditional SI group in terms of both their persistence to the end of the STEM course and the grades they earned for the semester. Moreover, the results were similar across subgroups, suggesting that online SI is a tool that can be useful for a broad cross-section of students at institutions of higher education. Consequently, it appears that online SI may be a viable replacement (or at least valuable complement) to traditional SI in postsecondary settings. However, more research needs to be done to see if these results can be replicated with future cohorts, as well as to investigate the extent to which there are differences in performance on more distal outcomes (e.g., year-to-year retention, cumulative GPA, graduation, receipt of a STEM degree, and so on) for the cohort who participated in SI in Spring 2015. Moreover, the extent to which sample members attend SI sessions needs to be examined in future studies and factored into associated analyses so that questions of minimal and optimal treatment dosage might be effectively addressed. (In the present study, implementation data limitations restricted the analytical focus to intent-to-treat.) Finally, the findings of future studies would be enhanced by varying on a weekly basis the order in which SI Leaders utilize specific session formats. For example, if a given SI Leader facilitates his or her online SI session first and the corresponding traditional SI session second in week one, the SI Leader would do the reverse in week two, facilitating the traditional SI session first and the online SI second. The third week, in turn, would repeat the order of the first week; the fourth week, the order of the second week; the fifth week, the order of the first week; and so on.

Future research by TAMUCC will investigate the extent to which these results can be replicated, and more distal outcomes might be impacted. Furthermore , TAMUCC will be taking a closer look at the relative effectiveness of online SI versus traditional SI in terms of specific STEM disciplines. To facilitate these investigations, TAMUCC will be implementing online and traditional SI and collecting data on additional cohorts in 2015-16, 2016-17, and 2017-18, as part of a comprehensive program of resources to produce definitive and consequential evidence of online SI's utility and effectiveness.

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Table 1

Baseline equivalence of academic achievement* for analytic sample

Group	*N*	n_t	M_t	SD_t	n_c	M_c	SD_c	*t*	*df*	*p*	*g*
All sample members	585	277	2.82	0.63	308	2.82	0.58	0.10	583	0.92	0.00
Females only	368	168	2.88	0.63	200	2.80	0.60	1.10	366	0.27	0.13
Males only	217	109	2.75	0.62	108	2.85	0.54	1.29	215	0.20	-0.17
Hispanics only	304	142	2.73	0.61	162	2.77	0.58	0.70	302	0.49	-0.07
Mathematics (MAT) 1442 students only	384	185	2.74	0.61	199	2.74	0.60	0.07	382	0.94	0.00

*As measured by pre-intervention, cumulative GPA

Table 2

Baseline equivalence of student socioeconomic status * for analytic sample

Group	*N*	n_t	n_t(Pell-eligible)	n_c	N_c(Pell-eligible)	*x2*	*df*	*p*	V	*OR*
All sample members	585	277	114	308	137	0.66	1	0.42	0.03	0.87
Females only	368	168	80	200	101	0.30	1	0.58	0.03	0.87
Males only	217	109	34	108	36	0.11	1	0.74	0.02	0.91
Hispanics only	304	142	69	162	88	1.00	1	0.32	0.06	0.79
MAT 1442 only	384	185	89	199	95	0.01	1	0.94	0.00	1.01

*As measured by Pell-grant eligibility status

Table 3

STEM course persistence of analytic sample

Group	*N*	n_t	n_t(Persisting)	N_c.	n_c(Persisting)	*x2*	*df*	*p*	V	*OR*
All sample members	585	277	255	308	278	0.58	1	0.45	0.03	1.25

Table 4

STEM course persistence by select subgroups (Females only, Males only, and Hispanics only) of analytic sample in STEM courses

Group	*N*	n_t	n_t(Persisting)	n_c	n_c(Persisting)	*Wald**	**df***		*Exp(B)**
Females only	368	168	155	200	182	0.10	1	0.75	0.47
Males only	217	109	100	108	96	0.69	1	0.41	0.68
Hispanics only	304	142	132	162	144	1.56	1	0.21	0.60

*Treatment (i.e., online SI vs. traditional SI) variable results from a binary logistic regression utilized to provide statistical control because baseline equivalence in cumulative GPA (cf., Table 1) is insufficient (i. e., effect size difference between groups at baseline is not :S 0.05)

Table 5

STEM course persistence by select subgroups (MATH 1442 students only) of analytic sample in STEM courses

Group	*N*	n_t	n_t(Persisting	N_c	n_c(Persisting)	*x2*	*df*	*p*	*V*	*OR*
MAT 1442 only	384	185	173	199	179	1.59	1	0.21	0.06	1.61

Table 6

Semester grades earned by overall analytic sample in STEM courses

Group	*N*	n_t	M_t	SD_t	n_c	M_c	SD_c	*t*	*df*	*p*	*g*
All sample members	585	277	1.88	1.28	308	1.91	1.25	0.36	583	0.72	-0.02

Table 7

Semester grades earned by select subgroups (Females only. Males only, and Hispanics only) of analytic sample in STEM courses

*Means adjusted via ANCOVA procedure with pre-treatment cumulative GPA as covariate. This ANCOVA

Group	*N*	n_t	M_t	SD_t	M_{t*}	n_c	M_c	SD_c	M_{c*}	*F*	*df*	*p*	*g*
Females only	368	168	1.94	1.22	1.90	200	1.97	1.25	2.01	0.99	l	0.32	-0.08
Males only	217	109	1.80	1.36	1.84	108	1.81	1.25	1.77	0.19	1	0.66	0.05
Hispanics only	304	142	1.68	1.25	1.71	162	1.88	1.20	1.86	1.40	l	0.24	-0.12

procedure was selected because baseline equivalence in pre-treatment cumulative GPA (cf., Table 1) was initially insufficient for these subgroups.

Table 8

Semester grades earned by select subgroups (MATH 1442 students only) of analytic sample in STEM courses

Group	*N*	n_t	M_t	SD_t	n_c	M_c	SD_c	*t*	*df*	*p*	*g*
MAT 1442 only	384	185	1.80	1.29	199	1.81	1.28	0.11	382	0.92	-0.01