

Successfully Applying the Supplemental Instruction Model to Sophomore-level Engineering Courses

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Abstract

Supplemental Instruction (SI) is a non-remedial program that utilizes peer-assisted review sessions and targets historically difficult academic courses. Although SI has been used nationally for decades, there is very little literature on its application in engineering courses. There is widespread evidence of its use in non-engineering and pre-engineering courses with varying degrees of success. Previous attempts to apply SI to mathematics courses at UNC Charlotte have proven difficult and were met with limited results. For over the past 15 years, SI has been offered at the university level. Only during the last four years has it become available in the College of Engineering.

Students believe that SI plays a key role in helping them build learning communities and study groups. Multiple assessment processes are balanced between quantitative and qualitative analyses including student, SI leader, and faculty feedback; attendance rates; final course grades; DFW rates (percentage of students receiving a course grade of D or F, or withdrawing from the course); and retention. Assessment results indicate that SI is making a statistically significant positive impact on final course grades and on DFW rates. Initial retention results also indicate that College of Engineering students who attended SI at least five or more times during a semester are more likely to be retained. Qualitative feedback from faculty suggests that SI participation is often the determining factor in whether or not a student repeats a course.

This paper focuses on the development, implementation, assessment, and continuous improvement of the program. Actual assessment results and lessons learned are presented.

Introduction

The philosophy, format, and objectives of SI are different from tutoring, problem sessions, recitation, and group study in several ways. First, SI focuses on high-risk courses, not on high-risk students. The courses selected for SI are those in which, traditionally, 30% or more of the students receive a final course grade of D or F, or withdraw from the course. Second, SI does not use a one-on-one format, but rather promotes and facilitates collaborative learning. Third, unlike group study, a specially qualified and trained peer leads the SI sessions. Fourth, SI leaders do not work problems for students.

Instead, SI leaders skillfully teach students *how to learn* by introducing them to and helping them apply academic success strategies. Most important is the fact that SI is not a remedial program. Therefore, *all* of the students enrolled in these courses are encouraged, but not required, to attend sessions. Students who have previously made an “A” in the course qualify to be an SI leader. Applicants are interviewed by the College’s program director and the course instructor(s) and are selected based on their technical competency, communication skills, and ability to work as part of a team. SI leaders are paid a small stipend and, typically, are contracted for 10 hours per week:

- three hours attending class
- one hour participating in the SI leader team meeting
- two hours preparing for SI sessions
- four hours conducting SI sessions

All SI leaders complete a two-day training under the supervision of the University’s SI coordinator before the beginning of the semester. The training includes topics related to how students learn, instructional strategies aimed at strengthening student academic performance, and mock SI sessions.

Despite the fact that he or she has already passed the course with an “A,” the SI leader is required to attend class so that: (1) the SI leader can observe what material is taught and how; and (2) the SI leader can identify concepts which may cause the students trouble. The latter is particularly important in the SI leader’s preparation and for providing real-time feedback to the course instructor. During the sessions, the SI leader does not “re-lecture” class material or work problems for the students. Rather, the SI leader teaches the students *how to learn* by coaching and guiding them through the understanding of and application of concepts. By facilitating discussions on how to draw system schematics, understand and use basic equations, and identify appropriate assumptions, the SI leader helps the students move beyond a “plug and chug” mentality. Based on feedback from course instructors and students who have participated in SI, peer-led sessions are effective in that students are more likely to ask questions, participate in group discussions, and take the lead in solving problems. Thus, SI provides a proactive environment in which SI leaders and students together compare notes, work problems, develop organizational tools, predict test questions, and have discussions about the course content. As a result, students identify and/or develop customized academic strategies to succeed in high-risk technical courses.

While SI promotes student interaction and collaborative learning, it also fosters a healthy interdependence, particularly evident when students learn by teaching others and when new perspectives and insights (whether correct or incorrect) are shared within the group. It is obvious that SI sessions also lead to the formation of study groups, which is one of the major strategies for ensuring persistence and improving retention.

According to Love and Tokuno¹, some of the characteristics that best describe learning communities are when students:

- Take the same classes.
- Form study groups for their courses.

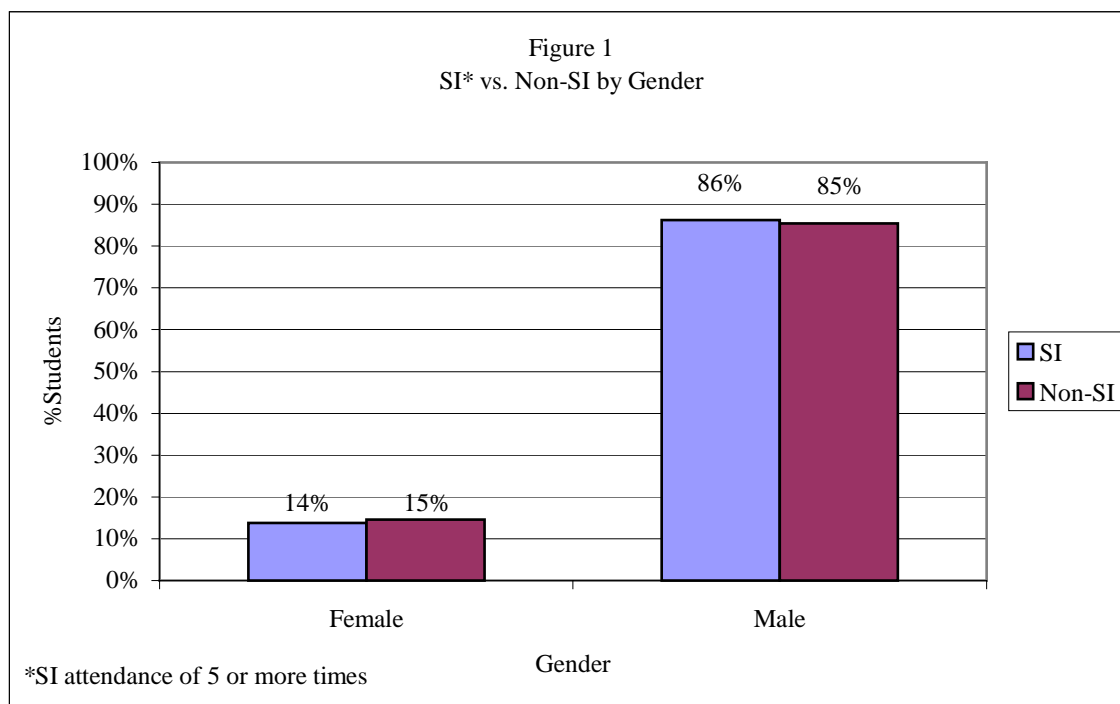
- Spend time socializing outside class.
- Share strategies for success.
- Collaborate on class activities and assignments that require them to work together and intentionally practice skills such as communication, cooperation, and/or conflict resolution.

All of the above statements could easily be used to describe any SI program. The program provides an environment conducive for building learning communities that includes the SI leader, students, and professors. Research has shown that student involvement in academic activities and faculty-student interaction are important factors for student success². SI fosters these kinds of activities and is a great tool for improving retention.

Who Attends SI?

College of Engineering attendance rates consider students who have attended five or more SI sessions per semester. Although many models use three or more sessions as the benchmark, it was determined that the more stringent standard would lend credibility to results and perhaps prevent allegations that students were more likely to attend only before tests.

Figures 1 and 2 compare the percentage of students, by gender and ethnicity, respectively, attending SI five or more times versus those who do not. The data reveal that there is virtually no difference in terms of who attends SI. It is interesting to note that the demographics of the students who attend SI are reflective of the demographics of general population of the college.



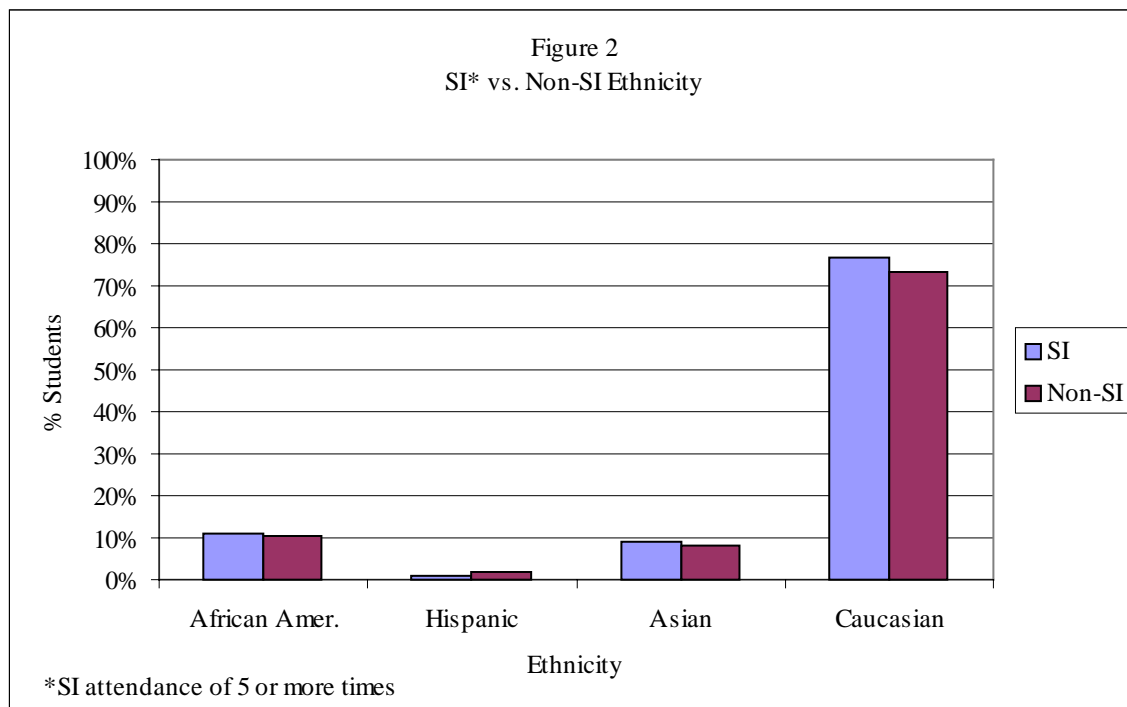


Table 1 shows average Math SAT, Verbal SAT and predicted GPA for students attending five or more SI sessions compared to those who do not. Again the data do not reveal a strong, if any, correlation between the incoming academic characteristics of the students and SI attendance. This invalidates the myth that only “good students” attend SI.

Table 1
Academic Preparation of SI versus Non-SI Students

| Avg. Math SAT | | Avg. Verbal SAT | | Avg. Predicted GPA | |
|---------------|--------|-----------------|--------|--------------------|--------|
| SI | Non-SI | SI | Non-SI | SI | Non-SI |
| 547 | 565 | 497 | 511 | 2.571 | 2.564 |

Assessing SI

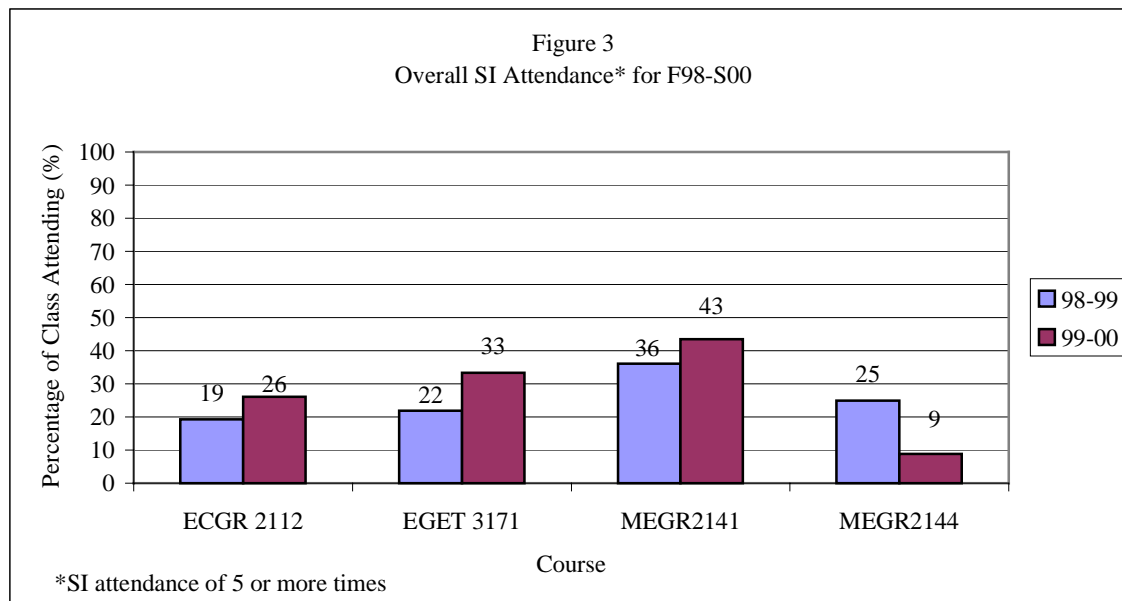
The success of SI in the College of Engineering is due mainly to an extensive and aggressive assessment protocol, regular reporting of results, a willingness to share what is working and what needs to be improved, and a desire to solicit and use feedback. The following graphs show the results for academic years 98-99 and 99-00, when SI was offered for MEGR 2141 (Statics), MEGR 2144 (Mechanic of Solids), ECGR 2112 (Network Theory II), and EGET 3171 (Applied Calculus for Engineering Technology students). Attendance rates, DFW rates, average GPA, and retention are tracked and reported each semester. In addition, surveys, focus groups, and interviews have also been used.

Attendance

Figure 3 compares the percentage of students attending SI five or more times during the 98-99 and 99-00 academic years. It should be noted that by fall of 1999, students were much more aware of the availability of SI than in previous years. Aggressive marketing and word-of-mouth promotion by students resulted in SI attendance rates that were typically more than double the national standard. Attendance increased for three of the four engineering courses in 99-00 compared to the previous year and, in 99-00, more than 40% of the students enrolled in MEGR 2141 had attended SI five or more times during a semester. It should be noted that during this same time, electronic SI (*eSI*) using the Internet was piloted for MEGR 2141 and 2144 to support the College's distance learning efforts. It is interesting that attendance rates for MEGR 2144 were drastically lower than attendance rates for the other courses during this same period. This finding is attributable to several factors:

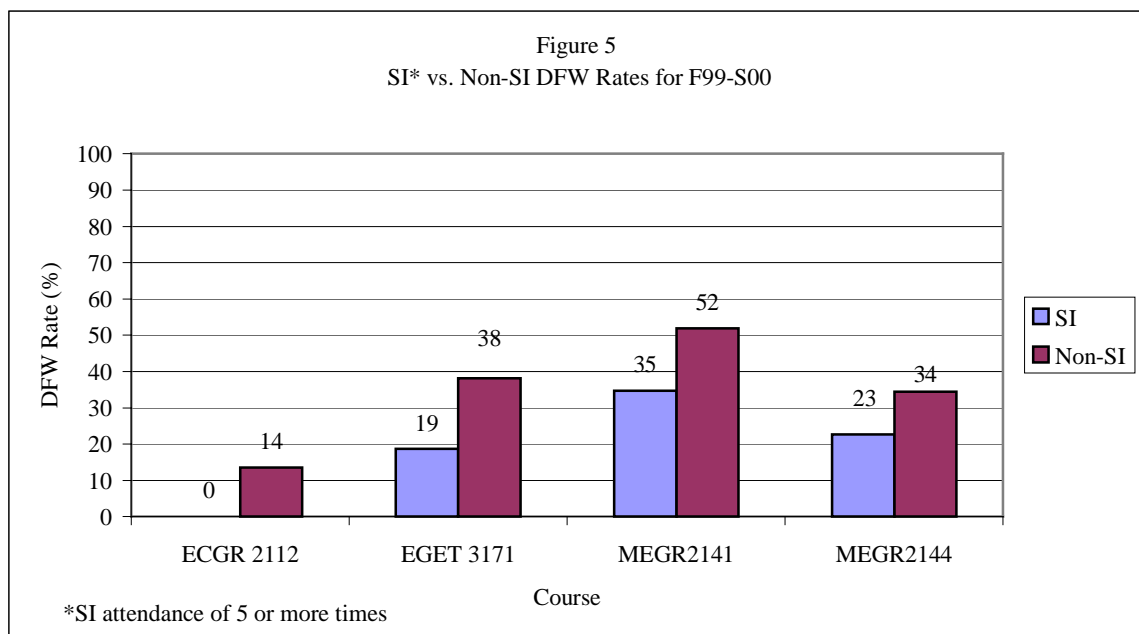
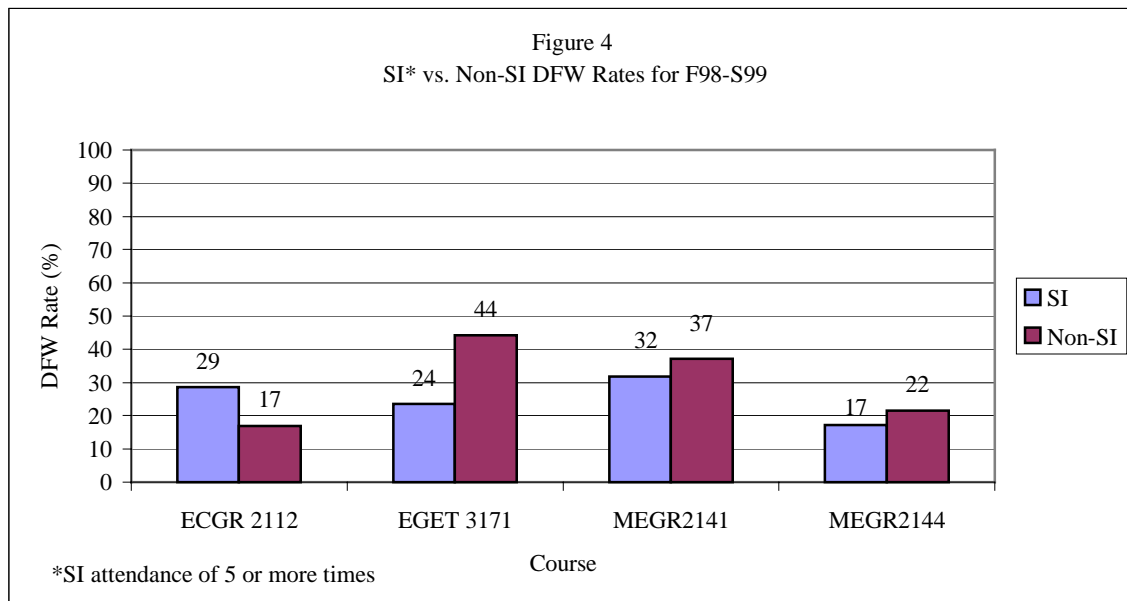
- Initially, only *eSI* was offered to on-campus and remote students enrolled in MEGR 2141. An on-campus component was not offered in conjunction with *eSI*, as in the case of MEGR 2144.
- The *eSI* pilot offered many lessons learned and opportunities for improvement.
- The choice of SI leader was, in retrospect, not the best choice.

Combined results for on-campus and *eSI* are included in the figures below. Sample sizes for *eSI* are too small to be statistically significant or meaningful to report separately.



DFW Rates

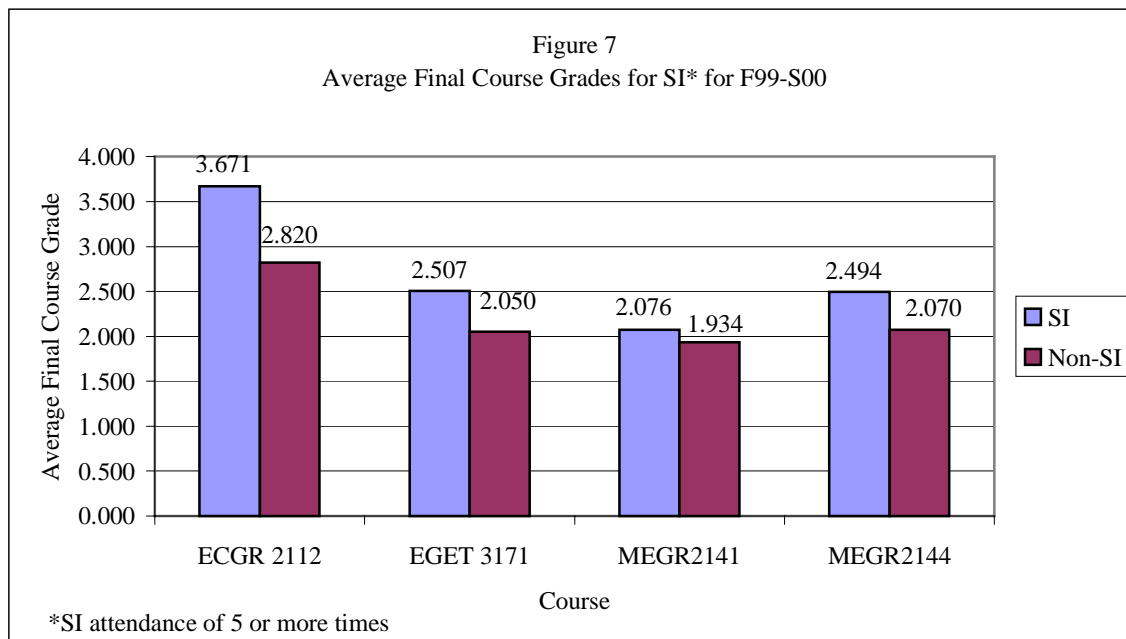
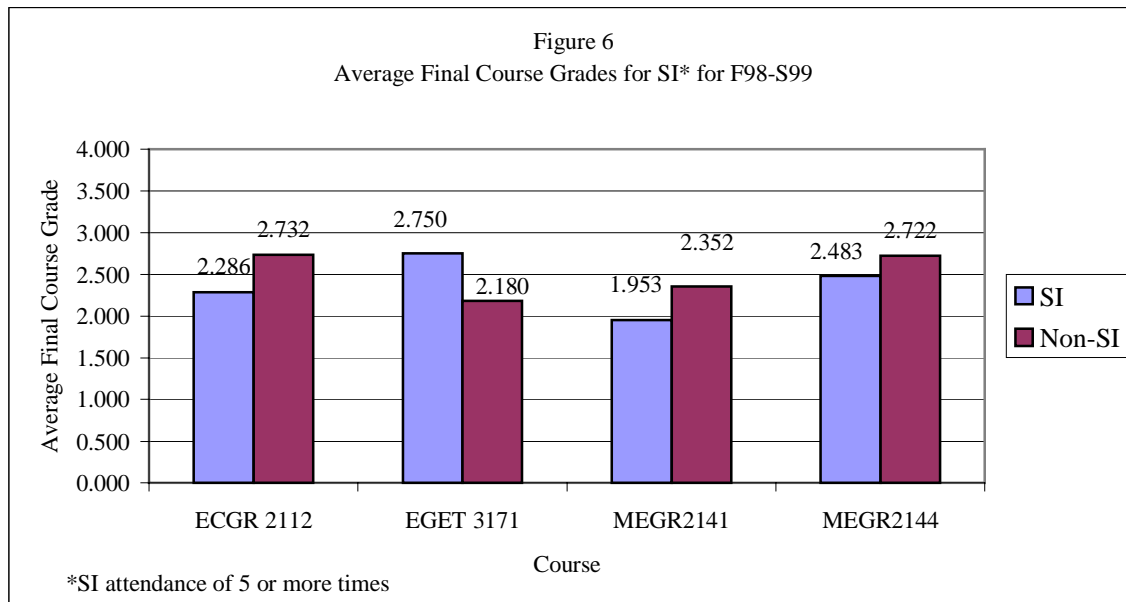
The DFW rate is the percentage of students who obtain a final grade of D or F, or who withdraw from the course. Figures 4 and 5 show the DFW rates for the respective academic years for students who attended SI five or more times a semester versus those who did not. Compared to the 98-99 academic year, the impact of SI on the DFW rate was much more impressive for 99-00 when SI was proven to have had a statistically significant impact on DFW rates.



Average Final Grade

Figures 6 and 7 compare the average final course grades for students attending SI five or more times a semester versus those who did not. The SI results shown in Figure 6 suggest that SI did not have a positive impact on average final course grades except for EGET 3171. However, follow-up with course instructors and students revealed that in many instances attending SI made the difference between passing and failing a course. In comparison, results for the 99-00 academic year, shown in Figure 7, were especially good. In three of the four courses, students who attended SI five or more times a semester received average final course grades of at least 20% higher than students who did not participate in SI as frequently. It is interesting to note that results

of a study conducted by Arendale³ corroborates that increased frequency of SI attendance typically yields higher final course grades. However, Arendale's study also revealed that sometimes students, who would have otherwise withdrawn from a course, often persisted and increased their SI attendance with the hope of passing.



Retention

Retention rates are obtained by tracking the students enrolled in a specific course and section for which SI is offered. Sophomore to junior (SO-JR) and junior to senior (JR-SR) retention rates are

used because, in the College of Engineering, SI is offered primarily for sophomore courses.

Retention rates were calculated for College of Engineering students enrolled in SI courses from fall of 1996 through spring of 1999. Since students typically take at least one year to be promoted, retention rates are based on students who were promoted to juniors or seniors as of spring 2000, the latest date for which data are available. Table 2 compares the retention rates for College of Engineering students attending SI sessions five or more times during a semester with those who did not. The retention rate for both sophomores and juniors who attended SI is 89%, which represents a difference of +10 points compared non-SI students. This result correlates with other studies conducted by Blanc, DeBuhr, and Martin.⁵

Table 2
College of Engineering SO-JR and JR-SR, SI and Non-SI Retention Rates

| SO-JR | | JR-SR | |
|-------|--------|-------|--------|
| SI | Non-SI | SI | Non-SI |
| 89% | 79% | 89% | 80% |

Effects of SI on Learning Communities

Without question, both students and faculty respond to Supplemental Instruction very well. Though this is very difficult to quantify, the feedback is obtained through surveys issued to students at the beginning and end of each semester and to course instructors at the end of the semester. In addition, focused individual interviews are held with students and instructors. Faculty members do not usually attend or participate in SI sessions, but they interact with both the SI leader and students on a regular basis. Offering the faculty a chance to communicate their perception of the program has provided greater opportunities for improvement by program administrators. When asked what they perceive to be the primary benefits of SI to the students, one faculty member wrote, "It gives them another window into the course, and it builds their self-confidence, [which is] critically important with about half the students." Faculty members are finding the numerous benefits of peer-to-peer facilitated study sessions and are showing increasing support for the SI program. Other comments provided by faculty members include the following:

- "Better understanding of the course material, including many aspects of A.C. circuit theory. Better active learning experience for the students than could be conducted in a lecture class. Collaborative learning at its best."
- "Extra exposure to subject material. Also, opportunity to ask questions."
- "A non-threatening chance to ask questions in a setting where it had no possibility of impacting their grade"

Surveys issued to the students at the beginning of the semester are used to determine their interest in attending SI sessions, reasons for not attending, expectations for study requirements and final course grade, and demographics (age, classification, etc). In fall 2000, 151 of these surveys were completed, and the compiled data reveal certain points of interest:

- 64% of students were "very interested" in attending SI, and 34% were "somewhat interested."
- Almost half (49%) of the students expected to study only three to five hours each week for the class. Suggested study requirement for a three-credit hour College of Engineering course is nine hours per week.
- 54% expected to get an "A," and 43% expected a "B" as the final course grade. As previously discussed, SI courses are selected based on notoriously high DFW rates. Consequently, these high expectations explain the general trend of low SI attendance at the beginning of the semester, but increasing after the first test.
- Most of the students surveyed were sophomores (40%) and juniors (55%), so high expectations regarding good academic performance with so little study time are quite surprising at this level.

Results of individual interviews conducted with students included the following findings:

- Students had definite expectations for both the attitude and behavior of the SI leaders.
- Starting early and starting strong is important to 'engage' students in the SI process.
- The interaction between the instructor and SI leader is critical in the eyes of the SI participants.
- Students did not anticipate the many ways SI would benefit them, i.e. from gaining a study partner or study group to having an opportunity to clear up 'muddy' points in course content.
- Having access to other like-minded students in and out of class was encouraging.
- SI provided an informal, encouraging, and non-threatening learning community.

Surveys, interviews, and other feedback mechanisms will continue to be included in the on-going assessment process.

Developing and implementing SI on your campus

Selling the concept of the Supplemental Instruction program model can be a difficult task. There are two distinct groups who need to buy into the program to result in a successful semester of SI. Both faculty and students must completely understand and believe in the SI approach. Initially, College of Engineering SI was met with resistance from the College administration and faculty, mainly because of funding constraints and because remnants of the "sink or swim" mentality still lingered. Seed money from a National Science Foundation Southeastern University and College Coalition for Engineering Education (SUCCEED) grant funded the first few SI offerings in fall 1996. Faculty skepticism did little to support the program or encourage students to participate. Additionally, at that time, students still preferred to work individually rather than in groups and competition among students did little to foster the collaborative learning style used in SI. Low attendance in spring 1997 forced the cancellation of statics SI in fall of the same year. Quite surprisingly, angry students deluged the program director insisting that statics SI be continued. SI was offered for statics again in spring of 1998, with a record (up to that time) 40% of the students attending five or more times during the semester.

Obtaining initial support and buy-in for SI was not easy. The first step was to identify "high-risk" engineering courses. According to the SI literature, "high risk" courses are those that traditionally have a DFW rate of 30% or more. Although these courses could have easily been identified

without data, historical trends proved to be a useful communication tool when soliciting buy-in. Once a course has been identified as a high-risk course where the SI model may be applicable, the instructor must be contacted and informed of the details of the program. The instructor needs to understand that the reason the course was selected for SI was not because of lack of teaching ability. Often, faculty who teach these courses are insistent that the students' failure to learn is a reflection of the students' lack of preparedness and motivation rather than their own ability to teach. This perception has proven to be the basis for initiating discussions about SI, because one of the most fundamental objectives of the program is to teach students academic success strategies.

Another important piece of the SI program is the SI leader. There must be good communication between the instructor, the SI leader, and the students. To gain support from the instructor and the students, the SI leaders must meet several requirements. SI leaders must be juniors, seniors, or graduate students in the College of Engineering. They must have a cumulative GPA of at least 3.0 and have good communication and academic skills. They must have made an A in the class, hopefully with the same instructor that is teaching the course. In addition, the SI leader must be able to attend the class. Finding students who meet these qualifications can be challenging, especially in engineering. Highly qualified technical students are in great demand in their own departments, the graduate school, other campus student support offices, and/or by local businesses. Moreover, engineering students have little time available due to the high demands of technical courses. Students and instructors are a great resource to identify SI leaders and the selection process should start several weeks before the semester starts. Once identified, the SI leader should contact the instructor to discuss session plans and ways to provide feedback, both to the students and to the instructor.

In order to maximize supplemental instructors' potential, it is essential to provide them with adequate program orientation and ongoing training. The structure of the training sessions are in a format similar to the SI sessions, but the agenda also includes topics relevant for preparing leaders to facilitate their sessions and troubleshoot some of the predictably difficult situations. Weekly interaction with veteran SI leaders is critical to the development of new SI leaders, regardless of the courses they are supporting. The skill to successfully "re-direct" student questions is common to all good SI leaders. This strategy initiates collaborative learning, which may then be translated into the study habits of the students throughout their other courses. According to one student that attended SI sessions, "You learn, in the session, about the thinking and learning styles of others and alliances easily emerge. The small group atmosphere is just conducive to interpersonal connections."

After the instructor has agreed to use an SI leader and the SI leader has completed the two-day training session, the program must be sold to the students. This is an important issue in engineering because of the competitive nature of the discipline. Again, support from the instructor is critical because the students will automatically value that which the instructor actively promotes as helpful to improving their grade and/or successfully completing the course. Students need to understand that SI is not a remedial program and not a tutoring session. The best way to describe a session is to attend one and experience the collaboration and energy it produces.

Advertising the SI sessions can happen in a variety of formats. After a set weekly schedule is

determined, most SI leaders will write the schedule on the board before class starts every day. Doing so provides an opportunity for the non-SI participants to see who the SI leader is and to remind previous attendees of when sessions are offered. This reminder also gives the instructor an opportunity to promote SI as he cleans the board or starts class. Other methods of promoting SI include posting the session's schedule in the appropriate places around campus and on the web, emails to the class from the leader, and classroom visits by the program director. Some SI leaders like to make bookmarks of the SI schedule to distribute to the class to keep in their textbooks.

Regular assessment and continuous improvement of the program is critical for obtaining support, both in terms of funding and resources, and for ensuring the long-term sustainability of the program. Specific data regarding attendance rates, DFW rates, retention statistics, and other relevant information, such as who attends SI and why, can help identify specific areas of concern and justify the cost/benefits of the program. It should also be emphasized that reporting the bad with the good also lends credibility to the process and presents an opportunity to seek input from faculty and students.

Conclusions

According to our results, SI has proven to be an effective tool for improving academic performance in College of Engineering courses. Students and instructors have commented that SI has had a positive impact on their way of teaching and learning. SI also has promoted community building and the formation of study groups. Over the years, the efficacy of SI has resulted in annual increases in funding from the College. In spring 2000, per the request of the department chairs, additional engineering courses, primarily at the junior and senior level, were added to the SI offerings using departmental funding. In fall 2000, again per the request of the department chairs, the departments assumed funding for engineering SI so that program funding could be reallocated to SI for chemistry, pre-calculus, and calculus in an effort to improve first-year retention. As a result, in less than five years the program has expanded from four courses in the fall of 1996 to eleven courses in the spring of 2001.

Acknowledgements

Funding for this work was provided by National Science Foundation Grant # EEC-9727411 to the Southeastern University and College Coalition for Engineering Education (SUCCEED) and by matching contributions provided by the University of North Carolina at Charlotte.

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