Introducing Supplemental Instruction to Mercer University Engineering Curriculum

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Abstract – Supplemental Instruction (SI) is an academic assistance program that utilizes peer-assisted study sessions. Mercer University has been offering SI sessions in different colleges through the university's Academic Resource Center for over thirteen years; however, Fall 2010 was the first semester in which the School of Engineering participated. Three courses were selected: Statics / Solid Mechanics, Thermodynamics, and Dynamics which are all instructed by Mechanical Engineering faculty. Since these courses represent engineering fundamentals and cover basic tools and techniques of mechanical engineering, they are often considered as mechanical engineering "weed-out" classes. The goal of SI instruction in these courses is to improve retention and graduation of engineers. This paper is focused on a comparison of test and final grades for the Fall 2010 and previous semesters. It consists of statistical analyses of those grades and students' attendance in SI sessions, and proves a significant positive influence of the pilot program on students' performance.

Keywords: Supplemental Instruction, weed-out courses

SUPPLEMENTAL INSTRUCTION IN ENGINEERING CURRICULUM

Supplemental Instruction (SI) is an academic assistance program that utilizes peer-assisted study sessions and targets high risk courses instead of high risk students. Developed by Dr. Deanna Martin at the University of Missouri at Kansas City in 1973 it has been proven by research to help students succeed. SI is offered on campuses around the world and targets historically difficult courses - those that traditionally have high rates of D's, F's and W's as final grades. Students who participate in SI learn how-to-learn while learning what-to-learn, work collaboratively with peer students in a facilitated environment, and receive support when needed [1].

SI sessions are regularly-scheduled, free of charge, informal review meetings in which students compare notes, discuss readings, develop organizational tools, and predict test items. Students learn how to integrate course content and study skills while working together. The sessions are facilitated by "SI leaders", students who have previously done well in the course and who attend all class lectures, take notes, and act as model students. SI leaders are trained in group facilitation techniques; they do not re-lecture, give class notes, or do homework. As one component of SI sessions, SI leaders incorporate explicit modeling of study and test-taking skills as are relevant to the content. SI leaders try to get students to actively think about what mental processes they used when they were successful and unsuccessful [2].

Student's approach to SI sessions changes over the course of the semester. At the beginning, the majority of the students attend the SI sessions with the attitude that they just want to get answers to their homework questions without making personal effort to think through their problems and develop a process. The SI leaders continually emphasize the fact that SI sessions are intended to help students understand the course material by thinking for themselves so they may learn an effective way of studying that could be applied to any technical course. Such a

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strategy works in motivating some students to make an extra effort while working on their homework even before showing up for the sessions [3].

National statistics indicate that students who attend SI sessions regularly can expect to earn final grades up to a letter grade higher than their classmates who do not attend SI. In addition to that, research results show the following benefits: Lower drop-out rate from these high-risk courses where SI support is implemented, improved critical thinking, studying and test-taking skills, and improved enrollment rate in subsequent semesters [2].

For peer leaders, the experience can be a transforming one, as well [4]. Not only do they gain a better understanding of the subject, they also become partners with faculty in implementing, documenting, and disseminating the SI programs. They become increasingly independent at performing these tasks and often become interested in taking on other leadership roles or become interested in pursuing careers that involve teaching and research. They make connections to obtain jobs or gain admission to graduate schools. Recent research findings point to the following gains when students take on the role as peer leaders:

- increased content knowledge and better success in higher-level science courses,
- increased confidence to pursue science-related careers,
- an appreciation for different learning styles,
- improved people skills and collegial relationship with the course instructor.

Since students attending SI sessions withdraw from "high-risk" courses less frequently than students who do not attend SI sessions, such courses are no longer high-risk by the definition and research shows that faculty feel that they are able to raise their course standards in these traditionally difficult-to-teach high-risk courses [5]. Faculty members' general perception about teaching these courses changed because they were provided with meaningful academic assistance with working with underprepared and unmotivated students.

The SI program has been proven to be an effective tool for improving academic performance in engineering courses [6]. Students and instructors comment that SI had a positive impact on their way of teaching and learning. SI also promotes community building and the formation of study groups.

SUPPLEMENTAL INSTRUCTION AT MUSE

Mercer University has been offering SI sessions in different colleges through the university's Academic Resource Center (ARC) for over thirteen years; however, Fall 2010 was the first semester in which Mercer University School of Engineering (MUSE) participated. Three courses were selected: EGR 232 "Statics / Solid Mechanics", EGR 235 "Thermodynamics", and EGR 236 "Dynamics" which are all instructed by Mechanical Engineering faculty. All of these courses are considered Engineering Core Sophomore subject areas and are required for all students for the BSE degree. The School catalog advises students to take Statics during the Fall semester of the Sophomore year, and Thermodynamics and Dynamics during the following semester. Dynamics requires Statics as a prerequisite. On average the population of Statics students in Fall semesters is twice as much as in Spring semesters, it is the opposite for Dynamics, and in Thermodynamics there is 30% more students in Spring than in Fall. Students specializing in Mechanical Engineering must achieve a grade of C or better in all three of these courses.

In addition to having larger section sizes (our regular classroom is designed for maximum 28 students), these courses:

- are often viewed as "weed out" courses to students who struggle to complete them successfully,
- are required and students feel they "have to be there",
- have exams that require higher order thinking skills,
- require large amounts of homework and additional practice outside of class.

While these attributes are common to most courses in engineering curriculum, these are perhaps the first courses in which students are confronted with this particular combination of demands.

In Fall of 2010 Mercer University School of Engineering offered three sections of Statics with two SI leaders, two sections of Thermodynamics with one SI leader, and one section of Dynamics with one leader. All sections had different instructors. All SI leaders were mechanical engineering seniors, have previously made an "A" in the

course, had high cumulative GPA and outstanding communication and academic skills. SI attendance in Thermodynamics and Dynamics was not mandatory while in Statics the following attendance rules were imposed:

- three SI sessions were offered every week by each leader (consequently six sessions for Statics)
- all students were required to attend at least one session per calendar week,
- one point was deducted from the student's final average for each week that no SI session was attended, up to a maximum of 5 points,
- the attendance requirement was waived for the remainder of the term for all students receiving a grade of 70% or higher on Test 2.

The influence of the SI program on students' grades can be seen in the following charts and tables. Figure 1 shows a comparison of fraction of D, F, and W grades for Tests 1 and 2 in Statics assigned by four different instructors over the last five years. The chart presents separate data for Instructor 1, 2, and 3 as these were the only lecturers participating in the SI program; however the total includes the 4th instructor who taught during the previous semesters. The Fall semester average is given separately since it is largely populated by students who are current with the catalog schedule. Because SI has only been administered in the Fall to date, this group provides the most meaningful comparison. Only one section is offered in the Spring semester, primarily for students who need to retake the course or are otherwise out of schedule (often transfer students). There is another section offered during the summer which is usually lightly populated. The instructors usually administer three tests during the semester and a final exam during the final week. On average the number of DFW grades decreased by 12% for Test 1 and 28% for Test 2 when Fall semesters are compared.

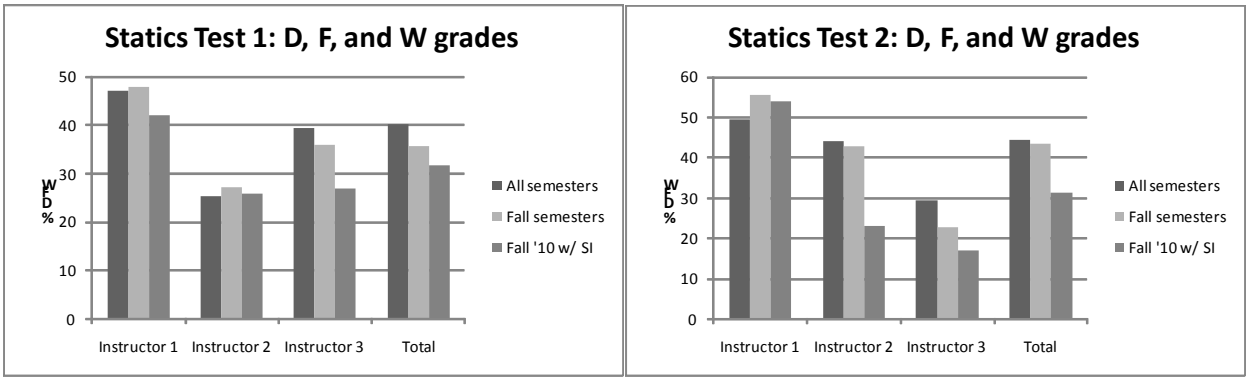

Figure 1. Percentage of D, F, and W grades for Test 1 and Test 2 in Statics course.

Figure 2 presents data and similar results for Thermodynamics course. The grades were collected over ten years for two instructors and once again Fall semester average was separated for more valid comparison with Fall semester SI. The percent of DFW grades decreased by 4% for Test 1 and 61% for Test 2 when Fall semesters are compared.

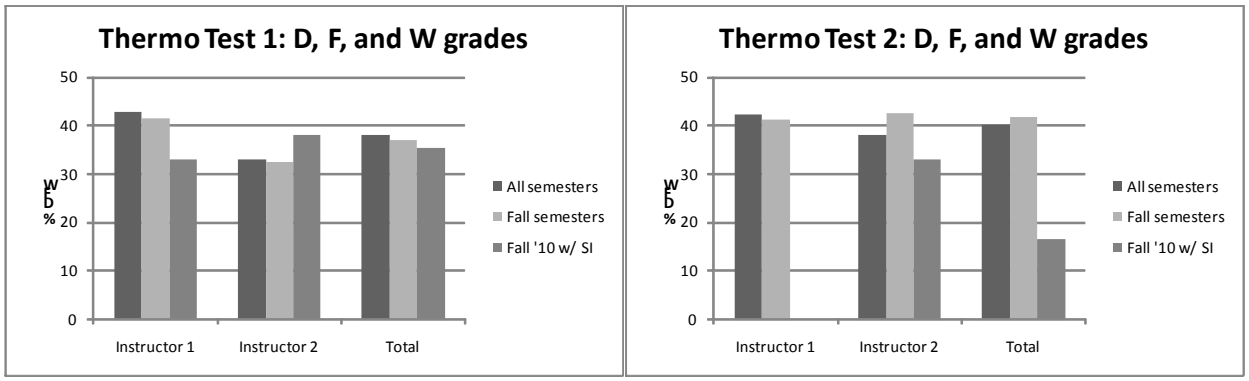

Figure 2. Percentage of D, F, and W grades for Test 1 and Test 2 in Thermodynamics course.

When the Fall 2010 semester came to an end all test scores together with final exam scores and final grades were compiled for all the instructors involved with this study and the results are presented in Figures 3 and 4. For Statics the required SI attendance seemed to help with Tests 1 and 2 only. The amount of DFW grades increased for Test 3 by 23%, for Final exam by 41%, and for Final grade by 6% when Fall semesters are compared.

For Thermodynamics and Dynamics courses, for which the SI attendance was voluntary, the trend with decreased DFW grades observed in Tests 1 and 2 continues for the following tests. For Thermodynamics the amount of DFW grades decreased by 33% for Test 3, by 9% for Final exam, and by 21% for Final grade when Fall semesters are compared.

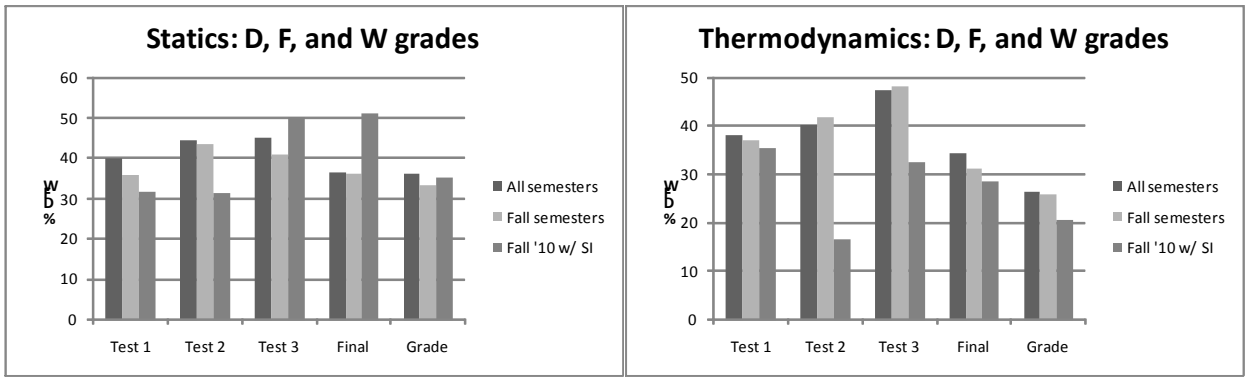

Figure 3. Percentage of D, F, and W grades for Test 1, 2, 3, Final Exam, and Final Grade in Statics and Thermodynamics

A comparison of percentage of DFW grades in Dynamics for Fall '09 and Fall '10 for two instructors collected over last four years is showed in Figure 4. The number of DFW grades dropped by 80% for Test 1, by 58% for Test 2, by 35% for Test 3, by 12% for Final exam, and by 45% for Final grade. It is worth noting that the Fall grades are lower than the yearly average, probably since it is a section populated by students who are off-schedule.

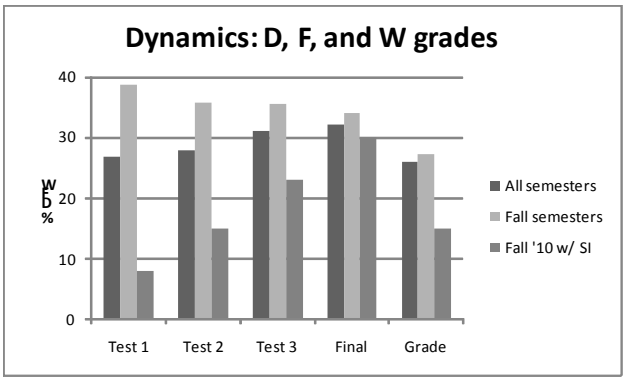

Figure 4. Percentage of D, F, and W grades for Test 1, 2, 3, Final Exam, and Final Grade in Dynamics course.

A closer look at the influence of the offered SI program is based on students' attendance in SI sessions as presented in Table 1. Score averages for Tests 1, 2, 3 and Final in the three courses are calculated for the whole class, for those who did not attend any of the SI sessions (obligatory in Statics and voluntary in Thermodynamics and Dynamics), for those who attended at least one session, and finally, for those who attended 3 or more. SI attendence (number of students' visits) for Tests 1, 2, and 3 is given for the periods between the tests, while the numbers for Final exams are based on the whole semester. The comparison of score averages can be seen in Figure 5.

Table 1. SI Test Reports for Test #1 and #2 in Statics, Thermodynamics, andDynamics courses.

	Statics				Thermodynamics				Dynamics			
	T 1	T 2	T 3	Final	T 1	T 2	T 3	Final	T 1	T 2	T 3	Final
Total Number of Test Takers	85	78	76	76	27	25	25	25	13	12	12	12
Average Test Score Overall	75.7	77.7	70.9	68.8	75.8	85.8	74.7	77.1	82.5	79.4	79.7	76.3
SI Attendance (# of visits) % Students	278 95%	378 99%	109 59%	757 99%	34 60%	27 57%	18 41%	78 73%	24 69%	16 75%	16 75%	54 75%
Average Test Score for non-SI	78.5 n=4	85 n=1	76.8 n=33	83 n=1	70.2 n=12	79.1 n=12	66.5 n=16	55.5 n=8	82.8 n=4	80.1 n=3	74.7 n=3	81.9 n=3
Average Test Score for SI Attendees	75.6	77.8	68.1	68.7	78.4	91.3	84.3	81.1	82.4	79	81.3	74.4
Average Test Score for SI Attendees @ ≥ 3 sessions	77.5 n=64	79 n=65	63.8 n=18	68.3 n=72	88.6 n=5	95.3 n=3	97.5 n=3	77.7 n=9	82.2 n=5	78 n=3	79 n=2	73.6 n=8
Average Test Score for SI Attendees @ < 8 sessions				66.7								
Average Test Score for SI Attendees @ ≥ 8 sessions				70.1								

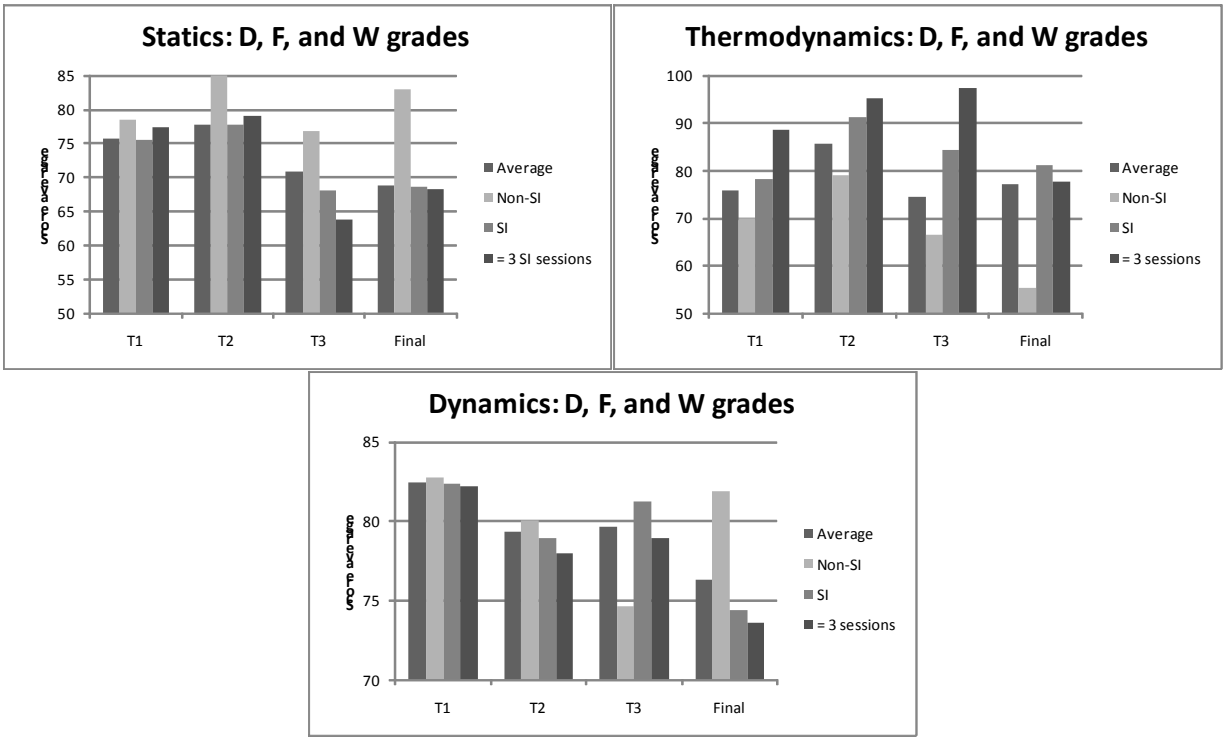

Figure 5. Average scores for Tests 1, 2, 3, and Final Exam for Non-SI and SI students

It is clear that in Statics there were students who did not need supplemental instruction and even though they decided not to attend the SI sessions, and despite the grade penalty, they proved to have better grade averages than those who attended them. At the end of the semester, out of 76 students who took Final exam, only one person did not attend any of the offered (six times a week) SI sessions. For those who attended, it can be observed that attending more than 3 sessions between tests gave better test scores for Tests 1 and 2, and worst scores for Test 3 and Final. However, it has to be remembered that only students who received below 70 on Test 2 were still required to attend SI as it became voluntary for the "better" students. Since all Statics students had at least 8 weeks of mandatory attendance, a comparison of Final exam averages for those who attended less than or equal-or-more than 8 sessions can be found in the last rows of Table 1. The more frequent attendance seems to result in better than average scores.

For Thermodynamics the trend for scores for SI non-attendees and those who attended, when compared to the average, is very clear. Non-SI students, about half the class, had lower test grades, while the SI-attendees always scored higher. The more frequent attendance gave even better scores in Tests 1, 2, and 3. However, this trend did not repeat for the Final exam.

In Dynamics, with approximately three-fourths of the class attending the SI program, the trend in grades is similar to that for Statics. In Tests 1, 2, and Final, non-SI students scored better than average, and the SI-attendees scored worse, especially those who participated in the program more frequently. The situaton changes to the opposite behavior for Test 3, with SI-attendees scoring higher; however the frequent attendees still do worse than the average.

STUDENT'S PERCEPTION

Mercer's Academic Resource Center surveys students participating in the SI program at the end of the semester. One of the questions in the survey is to rate the program on a 5 point Likert scale, where 5 is "very helpful" and 1 is "not helpful." Only two sections of Statics, one section of Thermodynamics, and the only section of Dynamics were surveyed. Students' evaluations in Statics gave an average of 3.7 with 31% of students giving a 5 - "very helpful" ranking despite the mandatory attendance. The average rating in Thermodynamics was 4.75 with 75% giving a 5 score and 4.9 with 89% giving the highest ranking in Dynamics.

An independent study was performed by an Electrical Engineering professor after finishing his "Electrical Fundamentals I," a sophomore engineering core course that has to be taken by all engineering students. In his survey he asked for comments on any SI programs offered. The positive comments about SI included: "very helpful," "much needed, much appreciated," "helps preparing for tests, for better understanding," "SI instructors could teach at a pace that benefitted slow learners and helped to reinforce new concepts," and "SI is the only reason I passed any classes this semester." The only negative statements regarded mandatory attendance in Statics: "it being required at first made it not as helpful due to students who didn't care to be there," "the SI [leaders] could only work one problem at a time so there is usually a lot of waiting involved," "to make it mandatory will make it more of a distraction than helpful," and "I'm a sophomore in college, so if I need help in a class, I should have the initiative to attend SI. I didn't need SI for this course, so going to SI was a waste of time."

According to four engineering SI leaders the sessions were helpful and successful. The leaders received four hour training from the Academic Resource Center at the beginning of the semester. During the SI sessions they answered questions, picked exercises from the textbooks or solved problems suggested by the students. Often they allowed students to work out problems on the board and reviewed basic definitions before tests. They stated that attendance on weekends was sparse. Leaders handling more than one course section, in Statics and Thermodynamics, had to deal with different course content and schedule. They suggested a separate leader per each course section. In Statics, the mandatory attendance made the sessions crowded, especially before tests, and some students were there only for the sake of attendance and were involved in different activities, e.g. doing homework for other courses.

CONCLUSIONS

Based on evaluation of test results we can conclude that the SI pilot program at MUSE had a significant positive influence on students' performance. When compared to previous semesters the grades improved in a significant

way through decrease of D, F, and W grades during and at the end of the semester, especially in Thermodynamics and Dynamics. In the case of Statics, the first computational engineering course the students take, the positive influence on the grades is seen during the beginning of the semester for the first two tests, but the situation changes for the third test and the final exam. The final grade appears to be unaffected. Data from additional semesters should be to be collected in the future in order to draw meaningful, statically significant conclusions.

Students not attending the SI program had better grade averages in Statics and Dynamics and worse in Thermodynamics. Students attending more than three sessions before a test had better averages in Statics and Thermodynamics and worse in Dynamics. Students attending more than 8 sessions during the semester in Statics had better final exam grade average. More data and further research will be necessary to determine and establish any important trends in these courses using SI.

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