Journal of Peer Learning

Volume 4 Article 4

2011

Improving student success in difficult engineering education courses through Supplemental Instruction (SI) – what is the impact of the degree of SI attendance?

Joakim Malm
Lund University, joakim.malm@kansli.lth.se

Leif Bryngfors
Leif.Bryngfors@kansli.lth.se

Lise-Lotte Mörner
Liselotte.Mormer@kansli.lth.se

Journal of Peer Learning (2011) 4: 16-23

Improving student success in difficult engineering education courses through Supplemental Instruction (SI): What is the impact of the degree of SI attendance?

Joakim Malm, Leif Bryngfors and Lise-Lotte Mörner

ABSTRACT

The customary way to determine whether an adopted Supplemental Instruction (SI) program has been successful or not is by comparing course results for two groups, SI attendees and non-attendees. The division of SI attendees and non-attendees is generally done rather arbitrarily by prescribing a minimum number of SI sessions a student has to attend to be considered an SI attendee. Although the SI attendee vs. non-attendee concept is powerful in some respects, it tends to cloud the benefit of attending SI sessions. That a higher SI attendance leads to better course results is perhaps taken for granted, but in the few further studies that have been made, the picture of SI attendance rates vs. course results is not overly clear. The present study aims to contribute to how the degree of SI attendance affects course results in an engineering context at a Swedish University. In the study we divide the students into four categories, those with high, average, low, and no SI attendance. In terms of student success in a course, it is found that there is a clear relation between the number of SI sessions attended and course success. Students with high SI attendance do best followed by students with average, low, and no SI attendance, respectively.

INTRODUCTION

Supplemental Instruction (SI) is an academic support program used at more than 1500 university colleges and universities in nearly 30 countries (Martin, 2008). It targets courses that have high failure rates and are considered "difficult" by the students (Hurley, Jacobs, and Gilbert, 2006). The main idea of SI is to process the course material by student discussions guided by a senior student – the SI-leader. The SI-leader is a facilitator, not a teacher, and presents no new course material. The senior student is trained in how to act as a SI-leader and is supervised throughout their tenure.

The standard when reporting on the impact of SI in course results for students is to divide the student population into SI attendees and non-attendees. Here, the cut-off is the minimum number of SI sessions participated in that is required to qualify as an 'SI attendee'. The cut-off differs between reported studies (if reported at all) but is usually within the range of one (Arendale 2001, Hensen and Shelley 2003, Webster and Hooper 1998) to five (Blat et al. 2001, Congos and Schoeps 1993, Rye et al. 1993, McCarthy et al. 1997). Although the SI attendee vs. non-attendee concept is powerful from the point of simplicity (either you are a SI attendee or not), it tends to cloud the

Published by the University of Wollongong

effect of the degree of SI attendance on student results. There are also relatively few studies where student results in courses have been related to the degree of SI attendance. Arendale (2001) compared the frequency of SI attendance upon mean final course grades for 1590 students at the University of Missouri - Kansas City USA and found a weak tendency towards the more SI attended, the higher final grade received. A slight influence of SI attendance on final course results was also found by McCarthy et al. (1997) for an engineering course in the University of Witwatersrand, South Africa. At the University of Queensland, Australia, a more pronounced relationship between the course grade in a statistics course and the degree of PASS attendance (PASS is the Australian version of SI) was shown in a study by Miller et al. (2004). Likewise, McGee (2005), Murray (2006), O'Donnell (2004), and Cheng and Walters (2009) reported on clear relations between number of SI sessions attended and the final course result in eight randomly selected courses at Texas A&M University USA, an engineering course at Queensland University of Technology Australia, in accounting courses at Macquarie University, Sydney, Australia and in math courses at the University of Minnesota USA, respectively. That there is a relationship between the total number of SI sessions attended and final course results has also been reported by Van Lanen et al. (2000).

The present study aims to contribute more information on how the degree of SI attendance affects the results from first-year courses at nine engineering programs at Lund University, Sweden, based on the following research question:

- How does the degree of SI attendance affect student success in first-year engineering courses supported by SI?

THE SI PROGRAM AT THE SCHOOL OF ENGINEERING, LUND UNIVERSITY

The academic year at the School of Engineering (LTH) at Lund University, Sweden, is divided into four quarters (an autumn and a spring semester of two quarters each). Each quarter consists of seven weeks of scheduled classes and one week of exams. A full work load for a student is usually two courses each quarter. The SI program at LTH is normally attached to courses with comparatively high failure rates during the first two to three quarters in the first year. The aim of the SI-program is to help the new students adjust to university studies and get a good start at LTH. For the nine engineering programs considered in the present study, all have SI attached to one course for the first two quarters. In each quarter two-hour SI sessions are offered once a week to each student during week two to seven (thus, the maximum number of SI sessions a student can attend is six for each quarter). Seven of the engineering programs also have SI attached to one course during the first quarter of the spring semester.

RESULTS

The SI attendance for first-year students in each of the first three quarters of the academic year is given in table 1. The courses to which the SI program is attached plus course-specific SI attendance are presented in table 2. In the first quarter, 79% of the students attended at least one SI session. In the second and third quarters this percentage decreased to 61% and 53%, respectively. Likewise the average attendance decreased successively by quarter, from 51% in the first quarter to 34% in the second and finally down to 30% in the third. The percentage of students attending all six SI sessions in a quarter was 22, 11, and 7% in quarters 1, 2, and 3, respectively.

Table 1

Quarter	No. of students in courses with SI	Average attendance (%)	No. of SI sessions (% of students attending)						
			0	1	2	3	4	5	≥ 6
1	762	51	21	10	9	12	11	14	22
2	746	34	39	12	10	10	10	9	11
3	528	30	47	11	7	11	9	8	7

SI attendance in quarters 1-3 (of 4) in freshman engineering courses for the academic year 2009/10.

Are these attendance numbers low, high or average in a broader perspective? Internationally, there is no standard when reporting SI attendance percentages. The most common way is to report the percentage of SI attendees: however, the definition of an SI attendee varies from study to study, as mentioned above, and thus, comparisons are not easily made. The easiest and probably most understandable attendance percentage for comparisons is the percentage of students attending at least one SI session. Here, there is a vast data base at the University of Missouri - Kansas City (UMKC). From the data reported by Arendale (2001) the annual percentage of students at UMKC attending at least one SI session was in the range of 30–49% during the period 1980/81-1998/99. The total number of courses and SI participants (defined as attending at least one SI session) over this time-span was 525 and 19,962, respectively. Annual data from a Midwestern University in USA over the time period 1993/94-1999/2000 show an annual percentage of 18–33% of students attending at least one SI session (Hensen and Shelley 2003). The total number of SI participants during that time period was 9,678.Webster and Hooper (1998) reported a percentage of 37-43% of students attending at least one SI-session for three chemistry courses in 1995 at the University of Pittsburg, USA. The total number of SI participants was 247. Bruzell-Nilsson and Bryngfors (1996) reported that 45% of 1,260 students attended at least one SI session in 11 courses during 1995 at Lund University, Sweden.

Table 2

Course/Course module	Quarter	No. of students in course	No. of SI sessions (% of students attending)			
			0	1-2	3-4	≥ 5
FMAA01 Calculus in One Variable, part 1	1	310	27	23	23	27
FMAA05 Calculus in One Variable, part 1	1	452	16	16	24	44
FMAA01 Calculus in One Variable, part 2	2,3	296	36	21	20	24
FMAA05 Calculus in One Variable, part 2	2	341	40	21	18	21
FMA420 Linear algebra	2,3	326	44	22	20	13
FMAA01 Calculus in One Variable, part 3	3	156	56	11	16	17
KOOA01 Introductory chemistry	3	66	26	20	35	20
FMEA10 Mechanics	3	89	44	25	18	14

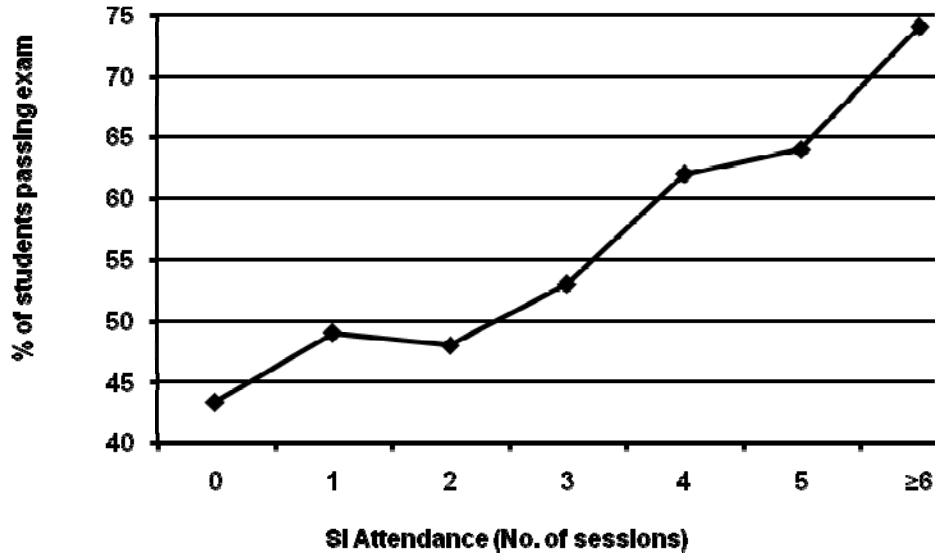
SI attendance in quarters 1-3 (of 4) in freshman engineering courses for the academic year 2009/10. FMAA01 and FMAA05 is the same course given at a different pace: FMAA05 is given over two quarters, while FMAA01 extends over three quarters.

With the above studies in mind, it can be concluded that the attendance percentages at LTH reported in the present study are high in comparison. The decreasing number of students at SI sessions in quarters 2 and 3 at LTH is perhaps not so strange since the students by then will have experienced exams at LTH and most likely formed a network of study partners, and probably do not feel the need to attend SI sessions to the same extent.

In order to get an overview of how SI participation affects course results, we start by comparing course results for SI attendees with non-attendees. If there are significant differences in course results the chances are most likely good for a meaningful

comparison of the degree of SI attendance and course results. However, in order to differentiate between SI attendees and non-attendees, we need to define the number of SI sessions that it takes for a student to adopt the SI methodology to such an extent that it makes a difference. This can be done roughly by using data from the first major exam in the course Calculus in One Variable and plotting it against SI attendance data, see figure 1. As shown in the figure, SI attendance has a pronounced effect on success in the first exam, but the differences are rather small in the span between 0-2 SI appearances. Attending more than 2 SI sessions, however, seems to result in clear improvements in course results. Therefore, we define an SI attendee as a student attending at least 3 SI sessions during a course.

Figure 1



Relation between SI attendance and the result on the first major exam in the course Calculus in One Variable. Results from in total 762 students registered on the course during the first quarter of the academic year 2009/10.

In table 3 the percentage of students receiving at least a passing grade in the investigated courses is given for both SI attendees and non-attendees. For all courses/course modules the SI attendees have lower failure rates than non-attendees. The differences are also statistically significant, except for the courses in Introductory Chemistry and Mechanics, having relatively small numbers of registered students.

Table 3

Course/Course module	Quarter	No. of SI sessions (% of students passing course)	
		0-2	≥ 3
FMAA01 Calculus in One Variable, part 1	1	51	66**
FMAA05 Calculus in One Variable, part 1	1	39	64***
FMAA01 Calculus in One Variable, part 2	2,3	34	61***
FMAA05 Calculus in One Variable, part 2	2	54	74***
FMA420 Linear algebra	2,3	65	81**
FMAA01 Calculus in One Variable, part 3	3	56	75*
KOOA01 Introductory chemistry	3	53	67
FMEA10 Mechanics	3	57	79

Percentage of students passing courses supported by SI as a function of SI attendance. FMAA01 and FMAA05 is the same course given at a different pace: FMAA05 is given

over two quarters, while FMAA01 extends over three quarters. Statistically significant differences in results using the chi-square test with $p < 0.05$, $p < 0.01$ and $p < 0.001$ compared to the student group who attended 0-2 SI sessions are marked with *, ** and ***.

The most suitable courses to study the effect of SI attendance rates on course results are Calculus in One Variable and Linear Algebra. Here, there is both a highly significant difference in course result between SI attendees and non-attendees and a comparatively high number of students who took the course. For the calculus course that exists in two versions (one faster, in two quarters and one slower, in three quarters) we consider two cases: one after the first quarter when the first part is examined and one after a full academic year when the whole course has been completed.

Before going into potential relations between SI attendance and examination results for specific courses we start by studying the relation between SI attendance and course results per quarter, see table 4. SI attendance is divided into four categories: No attendance, Low attendance (1-2 sessions), Average attendance (3-4 sessions), and High attendance (≥ 5 sessions). As can be seen in the table there is a clear and consistent relation for all three quarters. Students with high attendance are most successful in the courses, followed by students with average, low and no attendance at SI sessions, respectively. For all quarters the differences in course results are significant for students with high and average SI attendance records compared to students with no attendance at SI sessions. For students with low attendance, the better course results compared to non-attendees are significant for quarter two but not for the first and third quarters.

Table 4

Quarter	No. of students in courses with SI	No. of SI sessions / % of students passing courses with SI in quarter			
		None (0)	Low (1-2)	Average (3-4)	High (≥ 5)
1	762	43	48	57*	70***
2	746	48	61*	67**	72***
3	528	52	62	67*	88***

Percentage of students passing courses supported by SI during quarter 1-3 as a function of SI attendance. Statistically significant differences in results using the chi-square test with $p < 0.05$, $p < 0.01$ and $p < 0.001$ compared to the student group who did not attend SI sessions are marked with *, ** and ***.

If we now turn our attention to specific courses and start with courses/course modules spanning over one quarter (i.e., the first part of the calculus course [being very similar between the faster and slower versions] and the linear algebra course), the results are given in table 5. As above, we divide SI attendance into four categories: No attendance, Low attendance (1-2 sessions), Average attendance (3-4 sessions), and High attendance (≥ 5 sessions). From the table we can see the same picture as above, that a high SI attendance rate gives the best chances for success in the courses followed by average, low, and no attendance, respectively. For both high and average SI attendance the student results in the courses are significantly higher than for students who did not attend SI. For students with low SI attendance, the difference in course results compared to students with no attendance is too small to be statistically significant, although it is suggested that even this group benefits from SI to a smaller extent.

Table 5

Course/Course module	No. of students in course	No. of SI sessions / % of students passing course			
		None (0)	Low (1-2)	Average (3-4)	High (≥ 5)
Calculus in One Variable, part 1	762	43	48	57*	70***
Linear Algebra	326	63	68	77*	88**

*Percentage of students with at least a passing grade in 2 courses/course modules in the academic year 2009/10. Statistically significant differences in results using the chi-square test with $p < 0.05$, $p < 0.01$ and $p < 0.001$ compared to the student group who did not attend SI sessions are marked with *, ** and ***.*

For the full calculus course, eight engineering programs had SI sessions over two quarters and the maximum number of SI sessions a student can take is therefore twelve in this case. The results in terms of student success for different SI attendance rates are given in table 6. As above, we divide SI attendance into four categories: No attendance, Low attendance (1-4 sessions), Average attendance (5-8 sessions), and High attendance (≥ 9 sessions). Exactly as in the previous cases, students with high SI attendance are most successful in the course, followed by students with average, low, and no SI attendance, respectively. For the groups with high and average SI attendance the difference in course success is highly statistically significant compared to the student group who did not participate in SI sessions. As above, the difference in student success in the full calculus course between the group with low SI attendance and the group not attending SI is not statistically significant. However, the difference is big enough to suggest that the group with low attendance benefits from the SI sessions. The differences in student success between attendance groups are also greater than for the courses/course modules spanning over one quarter. This suggests that a student can affect the course result even more through high SI attendance over a longer time than in a course of shorter duration.

Table 6

	Attendance (No. of SI sessions)			
	None (0)	Low (1-4)	Average (5-8)	High (≥ 9)
Registered students in the course	118	179	173	173
Percentage of students obtaining at least a passing grade in the entire course after the first academic year	39%	49%	65%***	79%***

*Student success in the Calculus in One Variable course as a function of SI attendance. Statistically significant differences in results using the chi-square test with $p < 0.05$, $p < 0.01$ and $p < 0.001$ compared to the student group who did not participate in any SI sessions are marked with *, ** and ***.*

The observed differences above in course results between students with high, average, low and no SI attendance may of course be explained by other factors than SI attendance, at least partially. The most obvious such factor is differences in prior academic ability between the groups. In our case a measure of prior academic ability can be found from the grade point averages from secondary school. These grade point averages range from 10.0 (= pass) to 20.0 (=excellent). If we consider the groups with different SI attendance records investigated above, the differences in prior academic ability are small based on the secondary school grade point data. An illustration of this is given in table 7 for the exam results in the first part of the course Calculus in One Variable. Here, a measure of prior academic ability and its influence on exam results are presented for the four different SI attendance groups. As can be seen in the table both the differences in prior academic ability and their corresponding effect on exam results are small.

Table 7

	Attendance (No. of SI sessions)			
	None (0)	Low (1-2)	Average (3-4)	High (≥ 5)
Grade point average – mathematics in secondary school	17,1	17,2	17,4	17,5
Percentage of students passing first calculus exam	43 %	48 %	57 %	70 %
Percentage of students passing first calculus exam – "neutralised" with respect to grade point average	43 %	45 %	57 %	67 %

Prior academic ability and its effect on exam results in the first part of the Calculus in One Variable course as a function of SI attendance. The prior academic ability is measured by a grade point average from the five different course units in mathematics from secondary school that a student admitted to the faculty of engineering have to have. The "neutralisation" of exam results for the different groups with respect to grade point average was accomplished by using a linear regression model. The model related exam results for all students taking the exam with their grade point average.

CONCLUSIONS

In the engineering courses studied here, students attending SI sessions have clearly better success in the courses compared to non-attendees. There is also a clear relation between student success in the course and SI attendance rates. In the study we divided the students into four categories, those with high, average, low, and no SI attendance. In terms of student success in a course, students with high SI attendance do best followed by students with average, low, and no SI attendance, respectively.

AUTHORS

Joakim Malm, Leif Bryngfors and Lise-Lotte Mörner
Centre for Supplemental Instruction, School of Engineering, Lund University, P.O. Box 118, S-22100 Lund, Sweden

REFERENCES

Arendale, D. R. (2001). *Supplemental Instruction (SI): Review of research concerning the effectiveness of SI from The University of Missouri-Kansas City and other institutions from across the United States*. Retrieved 28 August 2010 from http://www.tc.umn.edu/~arend011/SIresearchreview01.pdf.

Blat, C., Myers, S., Nunnally, K. and Tolley, P. (2001). Successfully Applying the Supplemental Instruction Model to Sophomore-level Engineering Courses. *Proceedings of the 2001 American Society for Engineering Education Annual Conference & Exposition*, American Society for Engineering Education.

Bruzell-Nilsson, M. and Bryngfors, L. (1996). Supplemental Instruction: Student success in high-risk courses. The Faculty of Mathematics and Natural Sciences, Lund Institute of Technology, Sweden. *Paper presented at the ninth International Conference on the First-Year Experience*, St. Andrews, Scotland.

Cheng, D. and Walters, M. (2009). Peer-assisted learning in mathematics: An observational study of student success, *The Australasian Journal of Peer Learning*, *2*(1), 23-39. Retrieved 28 August 2010 from http://ro.uow.edu.au/ajpl/vol2/iss1/3.

Congos, D.H. and Schoeps, N. (1993). Does Supplemental Instruction really work and what is it anyway? *Studies in Higher Education, 18*(2), 165-176.

Hensen, K.A. and Shelley, M.C. (2003). The impact of Supplemental Instruction: Results from a Large, Public, Midwestern University. *Journal of College Student Development, 44*(2), 250-259.

Hurley M., Jacobs G. and Gilbert M. (2006). The Basic SI Model. In M. E. Stone and G. Jacobs (Eds.), *Supplemental instruction: New visions for empowering student learning* (11-22). New directions for teaching and learning. No. 106. Summer. San Francisco: Wiley Periodicals.

Martin, D. (2008). Foreword. *The Australian Journal of Peer Learning. 1(1), 3-5.*

McCarthy, A., Smuts, B. and Cosser, M. (1997). Assessing the effectiveness of Supplemental Instruction: A critique and a case study. *Studies in Higher Education, 22*(2), 221-231.

McGee, J.V., (2005). *Cognitive, Demographic, and motivational factors as indicators of help-seeking in supplemental instruction*. PhD thesis, Texas A&M University. 245 pages.

Miller, V., Oldfield, E. and Bulmer, M. (2004). Peer Assisted Study Sessions (PASS) in first year chemistry and statistics courses: insights and evaluations. *UniServe Science Scholarly Inquiry Symposium Proceedings*, 30-35.

Murray, M.H. (2006). PASS: primed, persistent, pervasive. *2nd National PASS Day Conference*. 10 July 2006. Gold Coast, Australia.

O'Donnell. R. (2004). Introducing peer-assisted learning in first year accounting in Australia, *Macquarie Economics Research Papers 12*, [Online] Retrieved 28 August 2010 from http://www.econ.mq.edu.au/research/2004/PALDec04.pdf.

Rye, P.D., Wallace, J. and Bidgood, P. (1993). Instructions in learning skills: an integrated approach. *Medical Education, 27*, 470-473.

Van Lanen, R. Lockie, N. M., and McGannon, T. (2000). Predictors of nursing students' performance in a one-semester organic and biochemistry course. *Journal of Chemical Education, 77*(6), 767-770.

Webster, T. and Hooper, L. (1998). Supplemental Instruction for introductory chemistry courses: A preliminary investigation. *Journal of Chemical Education, 75*(3), 328-331.