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Impact of Supplemental Instruction on dropout and graduation rates: an example from 5-year engineering programs

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

Leif Bryngfors
Leif.Bryngfors@kansli.lth.se

Johan Fredriksson
johan.fredriksson@stu.lu.se

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Impact of Supplemental Instruction on dropout and graduation rates: an example from 5-year engineering programs

Joakim Malm, Leif Bryngfors, and Johan Fredriksson

ABSTRACT

This study focuses on quantitative long-term effects of Supplemental Instruction (SI) in terms of graduation and dropout rates. One of the main aims of SI is to introduce students to effective study strategies and techniques. If SI is introduced at an early stage for new students in higher education, it should therefore be expected that this action will promote timely graduation. This has also been indicated in studies at two US universities – University of Missouri Kansas City and Utah State University. This impact should obviously be of huge interest to any college or university that wants to introduce SI for their students. However, more studies from different settings and environments are needed to be able to generalise the findings from previous studies. This investigation is one such study for students at an engineering education faculty.

The results from this study show that SI appears to have a pronounced effect on student persistence, and that the effect increases continuously with increasing SI attendance. A student's chances of graduating from an Master of Science (MSc) engineering program within six years, increases by approximately 20-35 % for a student attending all SI meetings in the first semester, compared to a student who does not attend SI. The risk of a student dropping out is reduced by approximately 20-40 % if he/she attends all SI sessions. The results also show that all students benefit from attending SI, independent of prior academic achievement and gender.

INTRODUCTION

Supplemental Instruction (SI) is a peer support program that targets 'difficult' courses, with the objective of improving retention and student learning outcomes. SI was created at the University of Missouri Kansas City (UMKC) in the seventies to meet the challenges of a continuously more diverse student population. Since then, SI has spread widely and members of more than 1,500 colleges and universities in 29 countries have been trained in the SI model (Martin, 2008).

In short SI can be described as a study group attached to a difficult course, under the guidance of a senior student, called an SI leader. The SI leader is a student who has already successfully completed the course. The SI leader does not act as a teacher in the sense that he/she introduces no new material nor reteaches presented course material. Instead, the SI leader is a facilitator in getting the students to address the challenges they face with the course material, and begins an SI session by getting the students to identify their difficulties. Thereafter, the SI leader initiates collaborative exercises addressing these difficult areas, where students share their knowledge and help each other towards understanding. The SI leader provides structure to student's work by asking questions or redirecting questions from the group back to the group, and helping them to become independent learners. In order for the SI leaders to be able to cope with this challenging task they receive an initial training and are continually supervised and coached during their service.

In 1981, the US Department of Education designated the SI program as an exemplary educational program. The US Department of Education has also validated three claims of the program (Martin & Arendale, 1992):

1. Students participating in SI within the targeted high-risk courses earn higher mean final course grades than students who do not participate in SI. This is still true when analyses control for ethnicity and prior academic achievement.
2. Despite ethnicity and prior academic achievement, students participating in SI within the targeted high-risk courses succeed at a higher rate (withdraw at a lower rate and receive lower percentages of D or F final grades) than those who do not participate in SI.
3. Students participating in SI persist at the institution (re-enrol and graduate) at higher rates than students who do not participate in SI.

The first two claims have since been validated repeatedly in different subjects and countries (e.g. Bruno, et al., 2016; Congos & Schoeps, 1993; Dancer et al., 2015; Fayowski & MacMillan, 2008; Kochenour et al., 1997; Longfellow et al., 2008; Malm et al. 2011; Miller et al., 2004; Sawyer et al., 1996; Summers et al., 2015). The third claim that SI causes the students to persist at the institution at higher rates has not received much attention. With respect to graduation, Martin & Arendale (1992) presented some general numbers that formed the basis for the third claim regarding 349 students at UMKC who, in 1983, had access to SI as new students. The cumulative graduation percentage during the period 1987-1989 showed that SI attendees consistently graduated at a faster rate than students not attending SI. However, no information was provided regarding type of studies and degrees, whether frequent attendees benefitted more, or if self-selection could explain at least part of the observed differences. Arendale (2001) presented similar findings based on the graduation rates in 1993-1996 for students who entered UMKC in 1989 and then had access to SI as new students. The study of Bowles et al. (2008) on the effect of SI on timely graduation at Utah State University included more students – 3,905 – and accounts also for prior academic achievement. They estimated that SI attendance, controlling for prior academic achievement, increased the probability of graduation within four years by approximately 11%. However, also missing here was information on the effect of the degree of SI attendance and the types of studies and courses.

Consequently, there is certainly room for more investigation of quantitative long-term effects of SI, in terms of graduation and dropout rates (is the third claim general or just limited to certain settings?). Furthermore, if SI is able to affect student long-term persistence – does the extent of SI attendance matter and do all students benefit, independent of prior academic achievement and gender?

These questions are also the research questions of the present investigation. Here we will focus on the long-term retention effects (dropout and graduation rates) of SI implemented in courses during the first semester of five-year MSc engineering programs at Lund University in Sweden. First, we will review factors that affect long-term retention of students and how SI can potentially have an impact on these factors. Next, we will outline the nature of the SI program at the Faculty of Engineering at Lund University. Thereafter we will describe the methodology of the study. Quantitative results on dropout and graduation rates with respect to SI attendance are followed by conclusions.

THE POTENTIAL IMPACT OF SI ON LONG-TERM RETENTION

A widely used model for student persistence in higher education was formulated by Tinto (1993). Central to the model is the link between academic environment and student retention. Specifically, for engineering, the studies of Vogt, Hocevar & Hagedorn (2007) and Vogt (2008) show that the academic environment affects academic confidence and self-efficacy, learning behaviours (effort, critical thinking, peer learning and help-seeking), and corresponding academic performance. Astin (1993) pointed out that the peer group is the most important environmental influence on student development. "By judicious and imaginative use of peer groups, any college or university can substantially strengthen its impact on student learning and personal development" (Astin, 1993). Astin's findings suggest that initiatives like SI can have a significant impact on student persistence and performance. More specifically, Tinto (2010) listed some key areas on which faculty can focus, in order to improve student retention:

- student and faculty expectations
- academic and social support
- academic and social engagement.

SI has the potential to affect all of these areas to at least some extent.

Expectations

The fact that SI employs successful senior students as SI leaders can certainly help in addressing expectations (see for instance Capstick et al., 2004). They know from their own and their friends' experiences what is needed to succeed, and can pass that on to the students attending SI (Allen & Court, 2009). Furthermore, they can translate faculty expectations regarding quality and level of effort needed (Court & Molesworth, 2008).

Support

Academic support is most effective when it is linked directly to a course and the class room, which is a core part of SI. SI is attached to a difficult introductory course to improve student success, potentially enhancing students' self-efficacy and increasing the likelihood of subsequent success. SI also trains the students' study ability and efficiency in areas such as (c.f. UMKC, 2006; O'Donnell, 2004; Capstick et al., 2004; Paideya, 2011; Bowles et al., 2008; Hammond et al., 2010; Court & Molesworth, 2008; Packham & Miller, 2000):

- critical review of course material and identification of important/difficult parts of the course on which to focus

- learning to work collaboratively, which potentially may deepen learning as well as making it more fun and interesting, and increasing student responsibility for the studies
- sharing different points of view on the course material to deepen one's understanding
- explaining the material to others and thereby reflecting on one's own understanding
- learning about effective study skills and strategies (such as note taking, structuring of course material, vocabulary acquisition, etc.) from fellow peers and the SI leader
- learning to take responsibility for their own studies, since the SI leader merely facilitates the learning process, and
- obtaining a more realistic picture of their own understanding in comparison to fellow students.

Social support is also a key part of SI. One main purpose is to find study partners and create a sense of belonging with other students – working towards a common goal (O'Donnell, 2004; Dobbie & Joyce, 2008; Capstick et al., 2004). Time is often allocated to discuss non-academic matters concerning school and life in general (Allen & Court, 2009).

Involvement

Student involvement is key in SI sessions in that:

- the work is done collaboratively in an easy-going and stress-free environment, which inspires learning (Tariq, 2005; Dobbie & Joyce, 2008; Capstick et al., 2004; Paideya, 2011)
- the students themselves decide what to focus on during SI sessions (Dobbie & Joyce, 2008; Capstick et al., 2004), and
- the SI leader puts the course material in a program perspective (Capstick et al., 2004) – where it can be used in later courses.

Thus, it can be concluded that SI has the potential to improve long-term retention.

DESCRIPTION OF THE SI PROGRAM AT THE FACULTY OF ENGINEERING AT LUND UNIVERSITY

SI has a fairly long history in the Faculty of Engineering at Lund University – it was introduced as a support program as early as 1994. Today the use of SI is widespread and SI exists in all engineering programs. SI is primarily used as a support for difficult initial courses (mainly in mathematics) during the first semester. Besides helping new students to succeed initially, the intention is also to maximise effects on long-term retention as described above. Each new student has access to one two-hour SI session per week during the first semester (totalling 14 SI meetings). Some engineering programs have chosen to extend SI to challenging courses during the second semester as well.

The group size in SI sessions is usually 5-15 students to optimise the chances of a good discussion climate. The meetings are facilitated by an older student and are based upon what the participants find difficult in the course. A typical SI session can, for instance, consist of a review of concepts or terminology, cooperation in small groups to answer complex questions or solve problems, or a review of (mathematical) proofs. Initially or in breaks, the SI leader may bring up questions regarding studies and student life in general. The SI leader also contributes with their own experiences and those of their study friends, and assists in putting course material in a program context. The SI leader is responsible for ensuring that the work is done collaboratively and is active in forming groups to obtain good group dynamics, allowing the participants an opportunity to collaborate with different individuals. The SI leader is also responsible for creating and maintaining an open and easy-going atmosphere to allow for all kinds of questions, guiding the work in the group by redirecting questions back to its members. The SI session usually ends with a summary of results from the session by the attendees.

As is clear from above, the demands on the SI leader are high, which makes the selection of candidates crucial. In order to become an SI leader, it is an important requirement that you have been an active participant on SI sessions yourself, and that you have been recommended by your SI leader due to high social competence and good understanding of the subject. Recommended students are invited to apply for the position. The applicants' study results are checked and they are thereafter called for an interview. Based on their application plus an interview, the students that best meet the expectations for an SI leader are selected. Usually about half of those applying are offered a position. The SI leaders receive two day's training in SI methodology and group management prior to their work. Thereafter they attend supervision meetings every second week, write a short reflective report after each meeting and are observed/coached twice per semester. At the end of the SI program both attendees and SI leaders fill in anonymous surveys. The intention with the surveys is to evaluate whether SI meetings were conducted in accordance with SI methodology, identify the benefits of attending SI and what could be improved upon, and establish whether SI really worked as a complement to the regular education. The survey, together with observations and supervision, are to ensure that the SI sessions were run in accordance with SI principles.

METHODOLOGY

An indication that participation in SI is linked to student persistence can be obtained by logging the attendance at SI, study results, dropouts, study leaves, and graduations. This was done for students beginning their five-year MSc engineering studies in autumn 2009 and 2010. In total, 1,617 students from ten engineering programs were included in the study. Attendance at SI sessions was optional. This self-selection process means that any established link between SI participation and student persistence, may be influenced by other factors that differ between SI attendees and non-attendees. However, by accounting for some obvious factors, such as academic proficiency and gender, we may reduce the uncertainties regarding any observed relations between SI and dropout, and graduation rates. Motivation is another obvious factor, but was not accounted for in this study. However, other studies on engineering students at Lund University did not show significant differences in motivation between SI-attendees and non-attendees (see Malm et al., 2011b; 2015; 2016). A measure of prior academic achievement for the new students was collected in the form of high school GPA in mathematics. High school GPA in mathematics, varying between 10 (pass) and 20 (excellent), has been shown to be more relevant to the engineering student performance at Lund University than the overall GPA according to Malm (2008). Gender differences between SI attendance groups was also considered. Female engineering students at Lund University tend to get better study results than male (Hell, 2012).

RESULTS

The students were divided into different SI attendance categories in order to investigate how the magnitude of SI attendance can potentially affect graduation and dropout rates (see Table 1). As seen in the table, the numbers of students are relatively similar in magnitude between the different attendance groups, which helps in validating comparisons between the groups. About a third of all students are female (32 %). Female students participate in SI to a slightly higher degree, and are overrepresented in the average and high SI attendance groups.

Table 1

Division of students from ten engineering programs at Lund University based on SI attendance. In total 1,617 students from the 2009 and 2010 cohorts. The number of female students is within parentheses.

SI attendance (No. of meetings)			
None	Low (1-5)	Average (6-10)	High (>10)
253 (51)	474 (127)	484 (176)	406 (165)

Does attendance at SI sessions affect both graduation and attrition rates for the investigated student group? The links between SI attendance and these factors are illustrated in Figure 1 and Table 2. As seen in both the figure and the table, there is a very clear relation between both graduation and dropout rates, and SI attendance. The chances of graduating appear to increase considerably the more you attend SI. After six years the percentage of students that have graduated in the group with high SI attendance is twice that of the group with students not attending SI (73% compared to 30%). The differences in graduation rates between attendance groups are largely a consequence of differences in students dropping out of engineering studies. The risk of dropping out seems to decrease considerably the more you attend SI. The comparison of attrition rates vs. SI attendance is, however, questionable if we consider all dropouts from day one. The SI program is run primarily over the first 3.5 months of the first semester. Therefore, students dropping out during this period have not had the same opportunity to attend SI as the rest of the students. Thus, the difference in dropout rates between the attendance groups are a bit exaggerated. In order to get a conservative estimate of the possible effect of SI on attrition rates, we therefore deducted the students dropping out during the first 3.5 months (see Table 1). Although the differences between attendance groups become smaller, the potential for SI to reduce dropout rates still appears to be large.

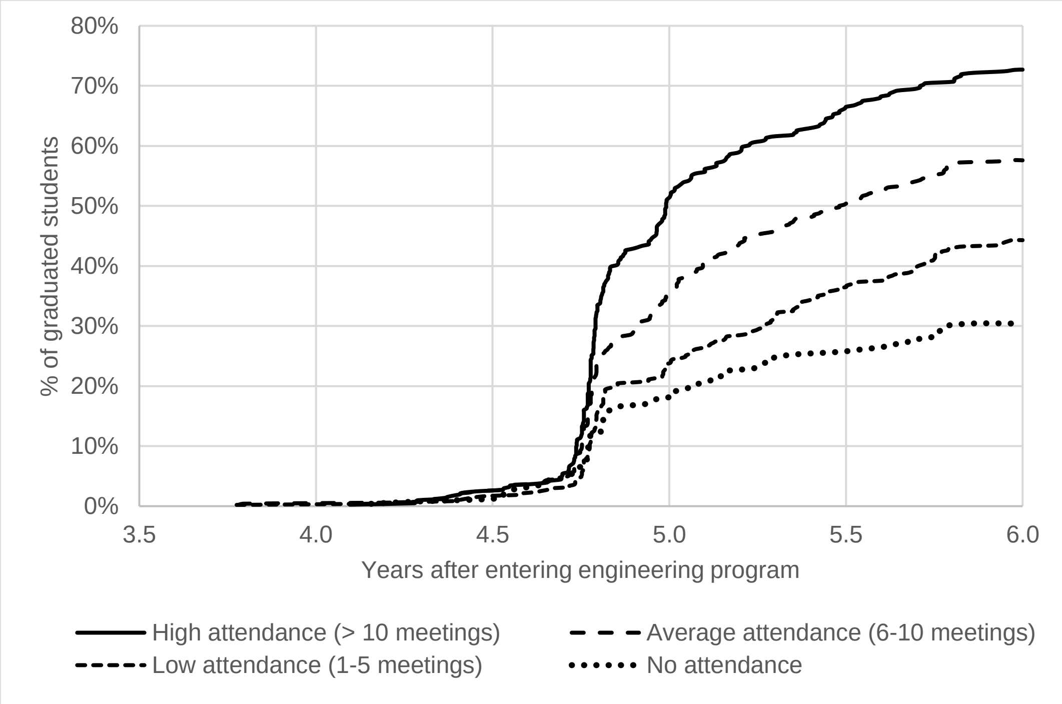

Figure 1. Percentage of students graduating from five year MSc engineering programs vs. SI attendance and time. Based on 1,617 students from ten different programs from the 2009 and 2010 cohorts.

Table 2

Student drop outs (% of all students) from ten engineering programs (students from the 2009 and 2010 cohorts) during the first six years vs. SI attendance. Dropouts after 3.5 months – the period of first semester SI meetings – are also given for a more unbiased effect of SI attendance on the dropout rate. 65 students dropped out in total from engineering studies during the first 3.5 months.

	SI attendance (No. of meetings)			
	None (0)	Low (1-5)	Average (6-10)	High (>10)
Dropouts (from day 1)	44 %	29 %	18 %	6 %
Dropouts (after 3.5 months)	31 %	23 %	18 %	6 %

It is certainly possible that the results in Figure 1 and Table 2 may not be entirely, or be at all, an effect of SI due to the fact that SI attendees are self-selected. This is a problem that cannot be completely overcome without very controlled studies where fundamental principles of SI may be violated (such as voluntary attendance). What we can do, however, is to control for a couple of the more obvious factors that can influence the potential link between SI attendance, and graduation and dropout rates. The factors included in this study are, as described above, prior academic achievement (expressed as GPA in mathematics in high school), and gender. In Table 3, graduation and dropout (expressed as binary values), are correlated with these factors and SI attendance after six years. Furthermore, SI attendance itself is correlated with these factors.

Table 3
Correlation between graduation, dropout (expressed binary, 1 = graduated/dropped out, 0 = not graduated/not dropped out) and SI attendance, and the factors prior academic achievement and gender (expressed binary, 1 = female, 0 = male). Based on 1,617 students from ten different engineering programs and two cohorts (2009 and 2010) after six years. Statistically significant correlations (using two-sided t-test) are marked in bold on p<0.01 level (corresponding to correlation values >0.064).

	High school GPA in mathematics	SI attendance	Gender
Graduation	**0.274**	**0.292**	**0.185**
SI attendance	**0.092**	**1**	**0.152**
Dropout	**-0.184**	**-0.291**	**-0.098**

From the table we can see that the correlations are all statistically significant, although this is largely due to the high number of students considered. It is clear that prior academic achievement, SI attendance and gender, matter for a student's chances of graduating or risk of dropping out of engineering studies within six years. SI attendance appears to be an important factor in both cases. Prior academic achievement, as measured by high school GPA in mathematics, also clearly affects a student's chances of graduating and to a lesser extent the risk of them dropping out. Gender is also a significant factor for graduation and to some smaller degree for dropping out. Female students graduate, on average, to a higher extent than male students and drop out to a lesser extent. The correlation of SI attendance with prior academic achievement and gender are small but significant in both cases. High achievers and female students are overrepresented among students who attend SI (the latter is also suggested in Table 1 above).

Thus, we have to account for prior academic achievement and gender when estimating the effect of SI on graduation and dropout rates. This will be done below by using a moderated logistic regression model, initially for describing the influence of these factors on graduation. The model can be expressed in terms of a probability, p, for a student graduating with an MSc degree within six years:

$$p = \frac{1}{1+e^{-Y}}$$
$$Y = \alpha_0 + \alpha_1 * SI + \alpha_2 * GPA + \alpha_3 * G + \alpha_4 * SI * GPA + \alpha_5 * SI * G$$

where *SI, GPA* and *G* are the student's SI attendance (number of meetings), high school GPA in mathematics and gender, respectively. The terms with *SI * GPA* and *SI * G* are included to consider the correlation between these factors. The coefficients α_n are determined based on the available data using maximum likelihood estimation. The estimation results in the present study give: α_0 = -4.240, α_1 = 0.207, α_2 = 0.108, α_3 = 0.710, α_4 = 0.0001, and α_5 = -0.021 (interaction terms are thus very small). Students who dropped out of engineering studies during the first 3.5 months have been removed from the data set in order not to bias the data with respect to SI attendance. Students without a Swedish high school GPA in mathematics have also been removed.

The graduation model's ability to describe the observed data is illustrated in Table 4. The collected data shows the effect and importance of SI attendance, prior academic achievement and gender on the student's chances of graduating within six years of entering engineering studies. The model gives a fair to good description of a student's graduation chances for the different scenarios, as seen in the last two columns in Table 4. Thus the model should be a good tool to illustrate the effect of SI attendance alone. This is done in Figure 2. The difference in graduation chances with respect to SI attendance is quite pronounced. The probability of graduating increases by approximately 20–35% for a student attending all SI meetings, compared to a student who does not attend SI. The magnitude difference is dependent on the student's gender and prior academic achievement. Both male and female students benefit from attending SI. However, male students with a high or average prior academic achievement, benefit more so than corresponding female students.

Table 4

Comparison of collected data and logistic regression model results for different groups with respect to SI attendance, prior academic achievement and gender. Data on high school GPA in mathematics, SI attendance and gender are averages for each group used as input to the model.

SI attendance group	No of students	High school GPA in math	SI attendance (No of meetings)	Gender (1 = female, 0 = male)	% graduated students	Model results – student probability (%) for graduation
High (> 10 meetings)	404	17.5	13.5	0.41	73 %	74 %
Average (6- 10 meetings)	469	17.2	8.1	0.36	60 %	60 %
Low (1-5 meetings)	432	17.0	3	0.28	45 %	45 %
None	206	17.2	0	0.20	37 %	37 %
GPA group in mathematics						
17.6 - 20	781	19.3	7.2	0.38	67 %	68 %
15.1 - 17.5	344	16.6	7.3	0.31	49 %	54 %
12.6 – 15	293	14.2	6.7	0.24	45 %	39 %
10 – 12.5	93	11.6	5.3	0.25	23 %	25 %
Gender group						
Female	498	17.7	8.1	1	68 %	70 %
Male	1013	17.0	6.4	0	50 %	50 %

A similar logistic regression model using GPA, gender and SI attendance as moderators can be used to predict the probability for a student dropping out of engineering studies. The corresponding expressions are the same and estimation results based on the collected data give: $\alpha_0 = 1.751$, $\alpha_1 = -0.142$, $\alpha_2 = -0.129$, $\alpha_3 = -0.179$, $\alpha_4 = 0.0002$, and $\alpha_5 = -0.006$ (interaction terms are very small). Also, this model describes the risk of a student dropping out fairly well for different scenarios, and we can thus use it to show the effect of SI attendance alone. This is done in Figure 3. It is apparent that all students seem to reduce the risk of dropping out of engineering studies by attending SI. Especially students with average or low prior academic achievement. A student entering engineering studies with the lowest GPA from high school can reduce the risk of dropping out by almost 40% by attending all SI sessions. Female students generally drop out to a lesser extent than male students, confirming the correlation data in Table 3. Both groups appear to benefit to the same degree by attending SI.

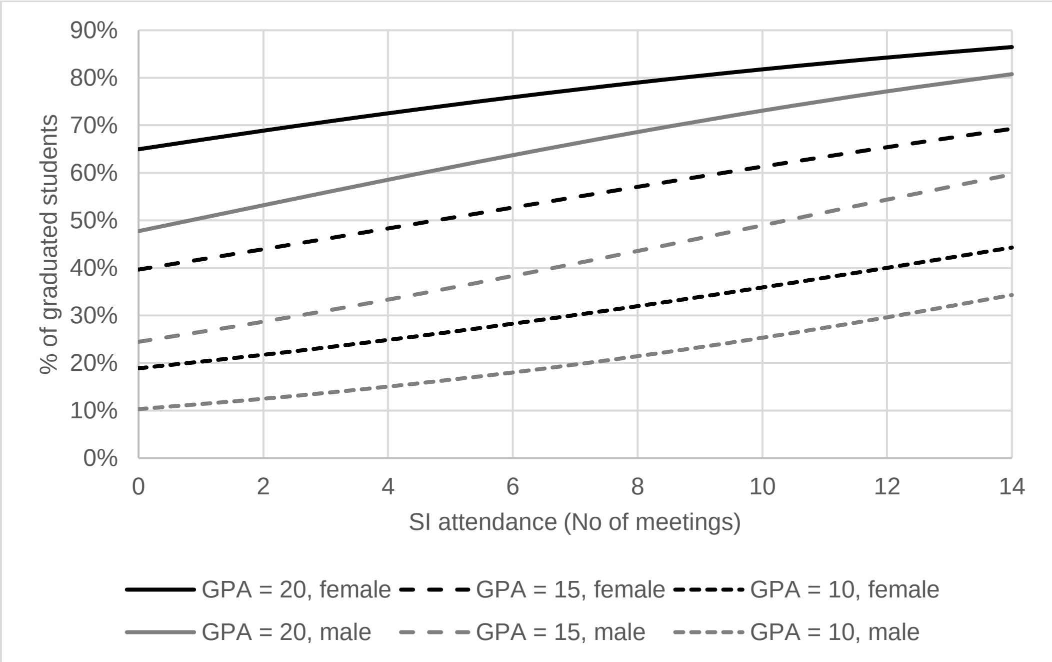

Figure 2. Logistic regression model results illustrating how attendance at SI meetings influences a student's graduation chances after six years.

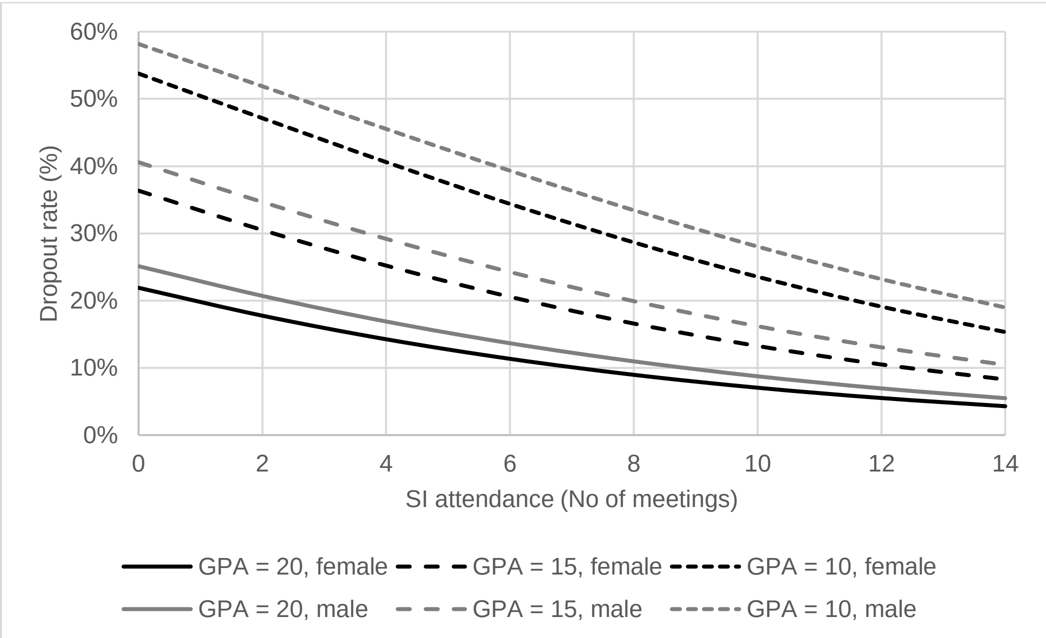

Figure 3. Logistic regression model results illustrating how attendance at SI meetings reduces the risk of a student dropping out of engineering studies within six years.

CONCLUSION

The present study focuses on the long-term impact of SI in engineering studies when SI is attached to difficult first semester courses. SI attendance seems to have a pronounced influence on both graduation and dropout rates in engineering. After six years of studies the percentage of students who have graduated in the group with high SI attendance is twice that of the group with students not attending SI (73% compared to 37%). Attrition rates are several times higher for students not attending SI compared to students with high SI attendance. However, these observed differences in graduation and dropout rates can partly be explained by factors other than SI attendance. Female students and students with better prior academic achievement have higher SI attendance. A correlation analysis for the present data set shows that both these student groups graduate to a higher extent and drop out in smaller numbers.

A logistic regression model was used to isolate the effect of SI. The results show that SI still appears to have a pronounced effect on student persistence and that the effect increases continuously with increasing SI attendance. A student's chances of graduating within six years increases by approximately 20–35% for a student attending all SI meetings, compared to a student who does not attend SI. The risk of a student dropping out is reduced by approximately 20–40% if he/she attends all SI sessions. The results also show that all students benefit from attending SI, independent of prior academic achievement and gender.

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